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(54) Title: FIBER CONNECTOR AND ADAPTER <div style="text-align: center;"> </div> (57) Abstract <p>Fiberoptic connector adapter assembly includes a fiberoptic connector received within an adapter. The connector (100) has a cover (166) on the connector housing (150). The cover (166) pivots between open and closed positions to expose or cover, respectively, an optical fiber contained within the connector (100). Longitudinal guides of the connector (100) are received cooperating with longitudinal guides of the adapter to direct the connector (100) into the adapter in a prescribed alignment. A cam pin is carried on the adapter to engage a cam pin receiving slot on the cover to urge the cover to the open position as the connector (100) is inserted into the adapter. A spring mechanism biases the cover (166) toward the closed position and open positions.</p>		

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FIBER CONNECTOR AND ADAPTER

II. BACKGROUND OF THE INVENTION1. Field of the Invention

- This invention pertains to connectors and adapters for optical fibers.
- 5 More particularly, this invention pertains to such connectors and adapters which include end caps for covering an end of the connector or adapter when the connector is not inserted into a mating adapter.

2. Description of the Prior Art

- Fiberoptic connectors historically presented exposed ends. Further, adapters which received such connectors presented exposed interior elements. The exposed ends and interior elements included the terminal ends of optical fibers. As a result, such terminal ends would be susceptible to impact damage or the like. Further, light transmitted through the optical fiber could inadvertently be directed into the eye of a technician or other person viewing the optical fiber or adapter.

- 15 The prior art has developed end caps for covering optical fibers when a connector is not in use. An example of such is shown in U.S. Patent No. 5,348,487 to Marazzi et al dated September 20, 1994. Figures 5 and 6 of the '487 patent illustrate two types of end caps which are pivoted to an open position as the end cap is placed within an adapter. Figures 7 and 8 illustrate an embodiment where a end cap 6 is pivoted to an open position and then slid rearwardly to expose a ferrule 5. An adapter for the connector is shown in Fig. 9. The adapter includes both an external housing 16 and an internal housing 15. The internal housing 15 includes a slot 30 which receives a pin 29 of the end cap 6. The slot 30 causes both the pivoting and the sliding action of the end cap 6 as the connector is placed within the adapter. Furthermore, the adapter includes an internal door 32 (shown in Fig. 10) which covers internal ferrules 2 when a connector 1 is removed from the adapter. Upon placement of a connector 1 into the adapter, the end cap is pivoted and slid to an open position and the door is pivoted to an open position. Further examples of such structures are found in U.S. Patents 5,420,951 and 5,363,460. These patents show fiberoptic connectors to be joined in adapters. While not SC adapters, the adapters shown in these patents are sized to have cross-sectional profile (i.e., footprint) the same as so-called SC adapters. An SC adapter is shown in commonly assigned U.S. Patent No. 5,317,663.

- 35 SC adapters are standard industry adapters having a fixed external size and geometry. The structure of the aforementioned '951, '487 and '460 patents

provide end caps and internal doors for the purpose of blocking light or protecting elements in connectors. However, the manner in which such functions are achieved restricts the density of fiberoptic connectors. Namely, in those patents, only single pairs of connectors may be optically coupled within a single adapter. Within the industry, it is desirable to provide up to two pairs of connectors being optically coupled in a single adapter. It is an object of the present invention to provide protective covering and doors for connectors and adapters in a structure that permits two connectors pairs to be coupled in an adapter having the same size as a standard size SC adapter.

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III. SUMMARY OF THE INVENTION

According to preferred embodiment of the present invention, a fiberoptic connector and adapter assembly comprises a fiberoptic connector with an optical fiber disposed within the connector housing. A cover is carried on the connector housing and pivots between an open and a closed position. In the closed position the cover closes an opening of the connector housing. In an open position, the cover exposes the opening. The connector housing includes a longitudinal guide aligned with a longitudinal axis of the connector housing. The cover further includes a cam pin receiving slot. A spring biases the cover toward the closed position. Preferably, the spring also biases the cover toward the open position when the connector is inserted into the adapter.

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The adapter includes an adapter housing sized to receive the connector housing. A fiber coupling mechanism is contained within the interior of the adapter to align with an optical fiber of an inserted connector. The adapter housing further includes a longitudinal guide which cooperates with the longitudinal connector guide to direct the connector into axial alignment with the adapter fiber coupling mechanism. The adapter housing further includes a cam pin disposed within the interior to be received within the cam pin receiving slot to urge the cover from a closed position to an open position as the connector housing is inserted into the adapter housing. The spring biased cover moves to a fully closed position when the connector is removed from the adapter.

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IV. BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a connector/adapter assembly including an SC adapter containing two pairs of optically coupled connectors;

Fig. 2 is an end elevation view of the connector/adapter assembly of

35 Fig. 1;

Fig. 3 is a view taken along line 3-3 of Fig. 2;

Fig. 4 is a view taken along line 4-4 of Fig. 3;

Fig. 5 is a front, top and side perspective view of the connector used in the assembly of Fig. 1 with an end cap shown in an open position;

5 Fig. 6 is the view of Fig. 5 with the end cap shown in the closed position;

Fig. 7 is an exploded perspective view of the connector of Fig. 5;

Fig. 8 is a front elevation view of the connector of Fig. 6;

Fig. 9 is a view taken along line 9-9 of Fig. 8;

10 Fig. 10 is a view similar to that of Fig. 5 showing an alternative embodiment of a connector which contains a ferrule;

Fig. 11 is the view of Fig. 10 with an end cap in an closed position;

Fig. 12 is an end elevation view of the connector of Fig. 11;

Fig. 13 is a view taken along line 13-13 of Fig. 12;

Fig. 14 is an exploded perspective view of the connector of Fig. 10;

15 Fig. 15 is the view of Fig. 3 with an alternative embodiment connector and adapter;

Fig. 16 is a view taken along line 16-16 of Fig. 15;

Fig. 17 is a perspective view of the adapter of the assembly of Fig. 1;

20 Fig. 18 is an end elevation view of the adapter of Fig. 17 with one door shown in a closed position;

Fig. 19 is a view taken along line 19-19 of Fig. 18;

Fig. 20 is a view taken along line 20-20 of Fig. 19;

25 Fig. 21 is the view of Fig. 19 showing an alternative embodiment adapter;

Fig. 22 is a view taken along line 22-22 of Fig. 21;

Fig. 23 is a side elevation view with internal elements shown in phantom lines of a connector of Fig. 11 being initially inserted into an adapter of Fig. 21;

30 Fig. 24 is the view of Fig. 23 showing additional insertion of the connector to a point where an end cap is about to pivot toward an open position;

Fig. 25 is the view of Fig. 24 showing still further insertion of the connector to a point where an internal door of the adapter is shown in the fully open position and the end cap is not yet to a fully open position;

35 Fig. 26 is the view of Fig. 25 showing still further insertion where the door is about halfway pivoted;

Fig. 27 is the view of Fig. 26 showing yet further insertion of the connector into the adapter with both the door of the adapter and the end cap of the connector shown in fully open positions;

Fig. 28 is a cross-sectional side view of a further alternative embodiment of a connector in accordance with the present invention, and including a spring biased cover;

Fig. 29 is a top view of the connector of Fig. 28;

5 Fig. 30 is a side view of the connector of Fig. 28 with the cover in the closed position;

Fig. 31 is a side view of the connector of Fig. 28 with the cover between the open position and the closed position;

10 Fig. 32 is a side view of the connector of Fig. 28 with the cover in the open position;

Fig. 33 is an exploded perspective view of the connector of Fig. 28 not showing the ferrule;

Fig. 34 is a side view of the outer connector housing of the connector of Fig. 28;

15 Fig. 35 is a top view of the outer connector housing of Fig. 34;

Fig. 36 is an end view of the outer connector housing of Fig. 34;

Fig. 37 is a side view of the cover of the connector of Fig. 28;

Fig. 38 is a top view of the cover of Fig. 37;

Fig. 39 is a end view of the cover of Fig. 37;

20 Fig. 40 is a side view of the spring pin of the connector of Fig. 28;

Fig. 41 is a top view of the spring pin of Fig. 40; and

Fig. 42 is an end view of the spring pin of Fig. 40.

V. DESCRIPTION OF THE PREFERRED EMBODIMENTS

25 With initial reference to Figs 1-4, a connector/adaptor assembly 10 is shown including four fiberoptic connectors 12 (each of identical construction) contained within a single adapter 14. The external geometry of the adapter 14 is the same as that shown in U.S. Patent No. 5,317,663. In other words, the cross sectional area of the adapter 14 is identical to that of a standard SC adapter such as that shown
30 in U.S. Patent No. 5,317,663 so that the adapter 14 may be inserted into preexisting applications which received the prior SC adapter of U.S. Patent No. 5,317,663.

The adapter 14 is separately shown in Figs 17-20 to which attention is now directed. The adapter 14 includes two halves 16, 16' joined at a flange 18. The flange 18 may be placed within a sheet metal support so that multiple adapters
35 14 can be positioned in side-by-side alignment on a sheet metal panel. Preferably, when the halves 16, 16' are joined, the part line between the halves 16, 16' is ultrasonically welded (or epoxied) so that the halves 16, 16' form an inseparable and solid adapter 14. Male and female rings, with close tolerances, may be provided at

the part line to assist with preventing moisture from penetrating the coupling from outside the adapter.

The top and bottom walls 20, 21 and sidewalls 36 of the adapter define an adapter housing having an longitudinal axis X-X. The adapter 14 presents a generally rectangular cross section perpendicular to axis X-X and including a major transverse axis Y-Y and a minor transverse axis Z-Z. An interior wall 22 extends along the longitudinal axis X-X and perpendicular to the major transverse axis Y-Y. The wall 22 divides the interior of the adapter housing into first and second chamber pairs 24, 24a and 24', 24a'. Connectors inserted within opposing chambers 24, 24a are optically coupled. Similarly connectors inserted into opposing chambers 24', 24a' are optically coupled.

The chambers 24, 24' are separated from the opposing chambers 24a, 24a' by interior wall segment 26 containing fiber coupling mechanisms 28, 28'. In the embodiments of Figs 17-20 the fiber coupling mechanism 28, 28' is a micro capillary sleeve 29, 29' contained within a cylindrical housing 31, 31'. The micro capillary sleeves 29, 29' have internal bores 30, 30' for receiving an optical fiber. The micro capillary sleeves 29, 29' are aligned with their axes being parallel to the longitudinal axis X-X and centrally positioned (relative to the major transverse axis Y-Y) within the chambers 24, 24'. The micro capillary sleeve includes a reservoir 35, 35' for receiving an index matching fluid to provide index matching between opposing optical fibers inserted into bores 30, 30'. An O-ring 53, 53' surrounds the exterior of the cylindrical housing 31, 31' at wall 26. The O-ring 53, 53' is sized with an outer diameter greater than a diameter of a forward opening 58 (Fig. 5) of the connector 12.

The use of micro capillary sleeves 29, 29' contained within the adapter 14 is for use with so-called ferruleless connectors such as those shown in Figs. 1-4. It will be appreciated that the present invention is also applicable to connectors which contain ferrules. In such an embodiment, the fiber coupling mechanism 28 is not a micro capillary sleeve but will include a split sleeve 29a, 29a' for receiving ferrules contained on the connectors. Such an embodiment is illustrated in Figs 21-22.

Doors 38 are pivotally secured to the upper wall 20 to pivot between an open position (shown on right hand side of the adapter in Fig. 19) and a closed position (shown on the left hand side of Fig. 19). The doors 38 are sized such that in the closed position, the doors 38 block direct visual inspection through the open ends of the adapter 14 to the fiber coupling mechanisms 28. As a result, in an event a fiberoptic connector is connected to one side of the fiber coupling mechanism 28 (e.g., the right side of Fig. 19), the closed door 38 on the opposite sides prevents a

technician from looking directly at light on the opposite side of the fiber coupling mechanism 28. The doors 38 are spring loaded to the closed position shown in Fig. 19 by springs 39. Stop posts 40 contained on opposing interior surfaces of the walls 36, 22 limit the movement of the doors 38 past the open position.

5 The adapter 14 also includes longitudinal adapter guides 42, 42' in the form of longitudinally extending rails which extend parallel to the longitudinal axis X-X in close proximity to the lower wall 21. At the open ends of the adapter 14, the upper wall 20 is provided with internally extending protrusions 44 for the purpose of locking a connector in place as will be described. Also, the opposing interior
10 surfaces of the walls 36, 22 include cam pins 46 for purposes that will be described. The doors 38 included cut out sides such that as the door 38 pivots to the closed position, the door 38 is free to pass both the cam pins 46 and the longitudinal adapter guides 42.

 With reference to Figs 5-9, the connector 12 includes an outer
15 connector housing 50. The connector 50 has a longitudinal axis X'-X' and a front end 52 having a major transverse axis Y'-Y' and minor transverse axis Z'-Z' (Fig 8). The major transverse axis Y'-Y' extends from a base wall 54 to a top edge 56. The front end 52 includes a connector opening 58 through which a terminal end of an optical fiber 60 extends. The optical fiber 60 is an extension of an optical fiber
20 carried in an optical cable 62 connected to the connector 12.

 Within connector 12, the fiber 60 passes through a mandrel 51 and a crimp 57 to define two crimp zones for crimping on the cable's reinforced fiber (not shown) and internal 900 μ m fiber 63. A strain relief boot 65 surrounds the mandrel 51 and cable 62. The interior of the housing 50 includes an internal cavity 67 (Fig.
25 9) to permit small amounts of displacement of fiber 60 as opposing fibers butt within the micro capillary sleeves 29 as opposing connectors 12 are optically coupled.

 To increase return loss, the fiber 60 is angularly cleaved. When opposing fibers 60 are mated in the index matching fluid within micro capillary sleeves 29, 29', the angular mating surfaces can be slightly overlapped (for example,
30 by several microns). The mechanical stress induced by connecting optical fibers can be reduced by the elastic properties of the fiber 60 accommodated by cavity 67.

 The hole 58 at front end 52 is an entrance to a cylindrical chamber 69 (Fig. 9) sized in close tolerance to the outer diameter of the adapter's cylindrical housing 31. An O-ring 55 is contained within chamber 69. O-ring 55 is sized with
35 an outside diameter greater than the internal diameter of chamber 69. The inside diameter of O-ring 53 is smaller than the outside diameter of cylindrical housing 31. The outside diameter of O-ring 53 is greater than the diameter of opening 58. As shown in Figs. 3 and 4, when connector 12 is fully inserted, O-ring 53 is squeezed

into opening 58. At the same time, O-ring 55 is squeezed. The O-rings 53, 55 keep any moisture or water from penetrating the optical coupling. With reference to Figs. 3 and 4, it will be appreciated that O-rings 53, 55 cooperate to provide circumferential and axial seals.

5 The housing 50 is sized to be received within any one of chambers 24, 24a, 24', 24a' of the adapter 14. The connector 12 includes a longitudinal connector guide in the form of longitudinally extending slots 64 on opposite sides of the connector housing 50. The slots 64 are parallel to the longitudinal axis X'-X' and are spaced from the lower wall 54. The slots 64 are positioned to receive the
10 guide rails 42, 42' when the connector 12 is inserted into the adapter 14 with the base 54 abutting the lower wall 21 and with the major transverse axis Y'-Y' of the connector 12 in parallel alignment with the minor transverse axis Z-Z' of the adapter 14.

 A cover 66 is pivotally secured to the connector housing 50 to pivot
15 about an axis Z''-Z'' which is parallel to axis Z'-Z' and spaced rearwardly of the front face 52. Fig. 5 shows the cover 66 in an open position exposing the opening 58 and the fiber 60. Fig. 6 shows the connector 12 with the cover 66 pivoted to a closed position closing the opening 58 and covering the fiber 60.

 The cover 66 includes a cam pin receiving slot 68 positioned at the
20 axis Z''-Z''. As will be more fully described, the slot 68 is positioned to receive the pin 46 when the cover 66 is in the closed position as the connector 12 is inserted into the adapter 14. The pin 46 rotates the cover 66 to the open position at which point the pin 46 exits the slot 68 upon further insertion. Removal of the connector 12 from the adapter 14 reverses the action so that the pin 46 causes the cover 66 to pivot
25 to the closed position.

 As shown in Fig. 7, the housing 50 includes two detents 70, 72. The cover 66 includes a pin 74. The detents 70, 72 and pin 74 are mutually positioned such that the pin 74 is received within the detent 72 when the cover 66 is in the closed position. The pin 74 is received within the detent 70 when the cover 66 is in
30 the open position. Positioning of the pin 74 within the detents 70, 72 acts to hold the cover 66 in a fixed position (i.e., either held in an open or closed position).

 The edge 56 includes a forwardly protruding cam surface 76 and a cut out portion 78. The cam portion 76 is disposed to engage the cover 38 as the connector 12 is inserted into the adapter 14. The cut out 78 is sized to receive the
35 pivoted cover 66 when the connector 12 is fully inserted into adapter 14 and the cover 66 is in a full open position.

 With prior art connectors, latches have been provided to secure a connector to an adapter. However, such latches commonly included voids into

which fibers could migrate and become caught or lodged. The present invention utilizes a connecting clip 80 having a free end 82 and an end 84 secured to the housing 50. The free end 82 is positioned between the front end 52 and the end 84 such that the cantilevered clip 80 points forwardly. The clip 80 includes a ramp surface 86 at the free end 82 to engage the protruding ledges 44 of adapter 14 when
5 fully inserted. Depression of the clip 80 frees the ramp edge 86 from the ledges 44 so that the connector 12 can be removed.

The rails 42 are received within the slots 64 to guide and direct the connector 12 in the desired direction of travel along axis X'-X'. The free end 82
10 includes a cutout to permit the free end 82 to pass the edge 56 in close tolerance (indicated by spacing 83 in Fig. 9) such that opposing surfaces of the edge 56 and free end 82 are separated by a spacing 83 smaller than the diameter of the cable 62. Accordingly, cable 62 cannot migrate inadvertently into the volume 85 (Fig. 9) defined between the opposing surfaces of the connector housing 50 and the clip 80.

15 With the construction thus described, two connectors 12 may be placed side by side into an adapter 14. As a result, the connectors 12 may be individually moved or inserted. From time to time, it may be desirable to couple adjacent connectors 12 so that they are simultaneously inserted or removed. A coupling clip 100 (Figs 1-4) is provided. The clip 100 includes a body portion 102
20 sized to match a spacing between adjacent connector housings 50 and configured to mate with the opposing surfaces of the connector housings 50. Pins 104 (Fig. 4) protrude from the body 102 and project into holes 105 (Fig. 5) in the connector housings 50. The clip 100 further includes a cap 107 to span the upper surfaces of the adjacent connectors 12. As a result, the spacer 100 securely connects two
25 connectors 12 so that they may be removed or inserted simultaneously. It will be appreciated that the spacer 100 is optional to permit connectors 12 to be individually or simultaneously removed or replaced at the option of a technician.

With the structure thus described, two connectors 12 may be placed in an adapter 14 having the same footprint of an SC adapter of prior art construction.
30 Further, both of the connectors 12 include pivoting end caps 66 for covering the fiber 60 contained within the connector. The adapter 14 includes a pivoting door 38 for covering internal optical components and shielding such components from the eye of a technician.

The foregoing description pertains to a ferruleless connector 12 and
35 mating adapter 14. The invention is also applicable to a ferrule-containing connector 12' and mating adapter 14'. These are illustrated in Figs. 10-21. Elements of this embodiment in common with the first described embodiment are not

separately described and are identically numbered with the addition of an apostrophe to distinguish the embodiments.

The connector 12' is separately shown in Figs. 10–14. The adapter 14' is shown in Figs. 21 and 22. Figs. 15 and 16 show an assembly of the connector 12' and adapter 14'.

Unlike the connector 12, connector 12' contains a ferrule 13' axially positioned in chamber 69' and protruding beyond the front end 52'. The ferrule 13' is contained within a hub 15' biased from a mandrel 51' by a spring 17'. The fiber 60' passes through the ferrule 13'. The adapter 14' contains a split sleeve 29a, 29a' to receive ferrules 13' and align opposing ferrules 13' and fibers 60' in axial alignment. In all other material respects, connector 12 and 12' and adapters 14, 14' are identical.

The sequence of operation of the device is best illustrated in Figs 23–27. In the embodiment shown in Figs 23–27, a connector 12' containing an internal ferrule 13 (such as that shown in Fig. 13) is shown being inserted into an adapter 14'.

In Fig. 23, the connector 12' is first inserted into the adapter 14'. The cover 66' is in the closed position and has moved the door 38' to cause the door 38' to pivot. The pin 46 is not yet received in the slot 68'. Fig. 24 shows further insertion where the pin 46 is just received in slot 68' but is not yet causing the connector cover 66' to pivot. The cam 76' is positioned to engage door 38'.

Upon further insertion, the view of Fig. 25 is attained where the cam edge 76' is engaging the door 38' to cause the door to pivot to an open position such that the cover 66' is free for pivotal movement. At this point, the pin 46' is urging against the slot surfaces 68' to cause the cover 66' to pivot. As the cover 66' pivots, the pin 74' moves out of the detent 72'.

Still further insertion is illustrated in Fig. 26 where the cam edge 76' retains the door 38' in the open position and where the cover 66' is not yet at a full open position but the ferrule 13' is exposed and aligned with the coupling mechanism 28'. At this point, the cover 66' is halfway through its full rotational movement as illustrated by the pin 74' being halfway between the detents 70', 72'.

Fig. 27 shows still further insertion where the cover 66' has been moved to its full open position with the pin 74' received within the detent 70' and with the cover 66' snugly received within the detent 78'. Further insertion of the connector 12' at this point causes the ferrule 13' to be passed into the fiber coupling mechanism 28 and for the clip ramp surface 86' to slide under and be captured by the retaining edges 44'. Upon depression of the clip 80', the connector 12' can be removed reversing the sequence of operation and causing the pin 46' to rotate the cover 66' to the fully down position. The spring 39 causes the door 38' to pivot to a closed position.

The foregoing details of the description of the present invention illustrates how the novel combination of novel connector and adapter achieve the functions of a cover of the end of the connector and a door within the adapter as well as permitting a design which permits two connectors to be fitted in side-by-side relation in a single SC adapter having the same cross sectional area as prior art SC adapters. Accordingly, the density is doubled over the density of prior art connectors having covers such as those shown in the aforementioned U.S. Patent No. 5,363,460.

Referring now to Figs. 28-42, a further embodiment of a connector 100 in accordance with the invention is provided with a spring biased cover 166 to ensure proper cover positioning during use. Cover 166 partially closed cannot be inserted into an adapter as the cam pins will be misaligned with the cam pin receiving slots on the cover. Connector 100 includes a connector housing 150 constructed generally in accordance with the connectors described above. Connector housing 150 includes two spaced apart side supports 152 including slots 154 and inwardly protruding shoulders 156. Slots 154 receive pivot pins 182 of a rotatable pin 180 for mounting a spring 200, as will be described below. Shoulders 156 allow pin 180 to snap into place. Side supports 152 further include outwardly projecting pins 158 for pivotal mounting of cover 166, as will be described below.

Cover 166 further includes recesses 170 for receipt of pins 158 of connector housing 150, thereby pivotally mounting cover 166 to connector housing 150. Cover 166 includes a spring projection 172 and a spring recess 174 for holding one end 204 of spring 200, as will be described below. Cover 166 further includes cam pin receiving slots 168, constructed generally in accordance with the connectors noted above.

The pivotally mounted pin 180 mounts an opposite end 202 of spring 200 to connector 100. Pin 180 includes pivot pins 182 defining a pivot axis for pin 180. A center section 184 includes a transversely extending spring projection 186, surrounded by a spring recess 188.

Spring 200 is a helical coil spring having a first end 202, and an opposite end 204. End 202 of spring 200 is received by spring projection 186, and spring recess 188, as shown in Fig. 28. Opposite end 204 of spring 200 is received by spring projection 172, and spring recess 174 of cover 166. Spring 200 is under compression and biases cover 166 toward the closed position as shown in Fig. 28. Should cover 166 be in a partially closed position, spring 200 will bias cover 166 toward the fully closed position, and will thereby move the cover to the fully closed position as shown in Fig. 28. In the fully closed position, cover 166 is positioned for alignment with the cam pins of an adapter, so as to open cover 166 during insertion. Such biasing of cover 166 toward the closed position is useful when connector 100

is initially inserted into an adapter after assembly, or after the connector is withdrawn from an adapter, and reinserted.

Spring 200 also preferably biases cover 166 toward the open position, when cover 166 is moved away from the closed position a predetermined amount, toward the open position. Spring 200 is pivotally mounted to connector housing 150 by pin 180 having a pivot axis defined by pivot pins 182 in slots 154 which is offset from the axis of rotation of cover 166 defined by pins 158 of connector housing 150, for example, see Fig. 34. During rotation of cover 166 between the closed and open positions, the direction of the normal spring force crosses over the radius defined by pins 158 and the contact point of spring 200 on cover 166 at spring projection 172 and spring recess 174. This crossover of the normal force creates an overcenter spring bias for biasing cover 166 toward either the closed or open positions depending on the position of cover 166 relative to housing 150 at the time. Biasing cover 166 in the open position is advantageous in that cover 166 is properly positioned for withdrawal of connector 100 from an adapter so that cover 166 is properly moved from the open position toward the closed position by the cam pins of the adapter.

Connector 100 is advantageously configured so that cover 166 is spring biased toward the closed position so that cover 166 is properly positioned for insertion into an adapter. Optionally, cover 166 is also spring biased toward the open position when inserted fully into an adapter. Other springs are anticipated for biasing cover 166 toward the desired position or positions.

It is intended that the specification and illustrated embodiments be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

WHAT IS CLAIMED IS:

1. A fiberoptic connector and adapter assembly comprising:
 - a. a fiberoptic connector having:
 - an outer connector housing having a longitudinal connector axis;
 - an optical fiber disposed within said connector housing and having a terminal end exposed through an opening in a leading end of said connector housing;
 - a cover carried on said connector housing and pivotally connected thereto to pivot between a cover open and a cover closed position, said cover in said cover closed position covering said opening, said cover in said cover open position exposing said opening;
 - a spring biasing said cover toward said cover closed position;
 - said connector housing including a longitudinal connector guide aligned with said longitudinal connector axis;
 - said cover including a cam pin receiving slot;
 - b. an adapter having:
 - an adapter housing having a longitudinal adapter axis and having walls defining an interior and an open end sized to receive said leading end with said longitudinal connector axis aligned with said longitudinal adapter axis;
 - a fiber coupling mechanism contained within said interior to couple with said optical fiber when said connector housing is inserted into said adapter housing to a fully inserted position;
 - a longitudinal adapter guide disposed to cooperate with said longitudinal connector guide to direct said connector opening into axial alignment with said fiber coupling mechanism as said connector housing is inserted into said adapter housing to said fully inserted position;
 - a cam pin disposed within said interior to be received within said cam pin receiving slot and urge said cover from said cover closed position to said cover open position as said connector housing is inserted into said adapter housing to said fully inserted position.
2. An assembly according to claim 1 wherein said spring has an overcenter position, wherein said spring biases said cover toward said cover open position after said cover is rotated by said cam pin past said overcenter position as said connector housing is inserted into said adapter housing toward said fully inserted position.
3. An assembly according to claim 1 wherein said spring is pivotally mounted to said outer connector housing.

4. An assembly according to claim 3 wherein said spring is a helical coil spring mounted under compression.

5. An assembly according to claim 1 wherein said cam pin is further disposed to urge said cover from said cover open position to said cover closed position as said connector housing is removed from said adapter housing.

6. An assembly according to claim 1 wherein:
said adapter housing includes an internal door disposed within said interior and movable between a door open position and a door closed position, in said door open position said fiber coupling mechanism exposed through said adapter open end, in said door closed position said door covering said fiber coupling mechanism;

a cam surface carried on said connector housing and positioned to urge said door from said door closed to said door open position as said connector housing is inserted into said adapter housing to said fully inserted position.

7. An assembly according to claim 1 wherein:
said adapter housing has a substantially rectangular cross-section perpendicular to said adapter longitudinal axis, said cross-section including a major transverse axis and a minor transverse axis;

said adapter housing including an internal wall extending parallel to said minor transverse axis and dividing said interior into first and second connector receiving chambers each sized to receive individual ones of said connector housings and each having respective ones of said fiber coupling mechanism, said longitudinal adapter guide and said cam pin.

8. An assembly according to claim 7 wherein:
said connector housing has a connector transverse axis perpendicular to both said connector longitudinal axis and a pivot axis of said cover;
said connector guide and said cam pin receiving slot disposed to align with said adapter guide and said cam pin when said connector housing is inserted into one of said chambers with said connector transverse axis parallel with said minor transverse axis.

9. An assembly according to claim 1 wherein:

said connector housing includes a retaining clip carried thereon for releasably connecting with said adapter housing;

said retaining clip including a movable end and a clip body having a fixed end secured to said connector housing, said clip body spaced from said connector housing to define a volume;

- 5 said retaining clip disposed for said movable end to be positioned between said connector opening and said fixed end.

10 10. An assembly according to claim 9 wherein said movable end is spaced from opposing surfaces of said connector housing by a distance less than a thickness of a fiberoptic cable secured to said connector housing.

11. An assembly according to claim 1 wherein both of said adapter and said connector include O-ring seals for sealing mating elements when said connector is inserted into said adapter.

- 15 12. A fiberoptic connector for mating with an adapter having an adapter housing having a longitudinal adapter axis and having walls defining an interior and an open end, a fiber coupling mechanism contained within said interior to couple with an aligned optical fiber, a longitudinal adapter guide aligned with said longitudinal adapter axis, a cam pin disposed within said interior, said connector comprising:

20 an outer connector housing having a longitudinal connector axis and sized for a leading end of said connector housing to be received within said adapter open end and with said longitudinal connector axis aligned with said longitudinal adapter axis;

25 an optical fiber disposed within said connector housing and having a terminal end exposed through a connector opening in a leading end of said connector housing, said fiber disposed for said terminal end to be coupled with said fiber coupling mechanism when said connector housing is inserted into said adapter housing to a fully inserted position;

30 a cover carried on said connector housing and pivotally connected thereto to pivot between a cover open and a cover closed position, said cover in said cover closed position covering said opening, said cover in said cover open position exposing said opening;

35 a longitudinal connector guide disposed to cooperate with said longitudinal adapter guide to direct said connector opening into axial alignment with said fiber coupling mechanism as said connector housing is inserted into said adapter housing to said fully inserted position;

 a cam pin receiving slot on said cover and disposed to receive said cam pin for said cam pin to urge said cover from said cover closed position to said

cover open position as said connector housing is inserted into said adapter housing to said fully inserted position; and

a spring biasing said cover toward said cover closed position.

5 13. A fiberoptic connector according to claim 12 wherein said spring has an overcenter position, wherein said spring biases said cover toward said cover open position after said cover is rotated by said cam pin past said overcenter position as said connector housing is inserted into said adapter housing toward said fully inserted position.

10

14. A fiberoptic connector according to claim 12 wherein said spring is pivotally mounted to said outer connector housing.

15 15. A fiberoptic connector according to claim 14 wherein said spring is a helical coil spring mounted under compression.

16. A fiberoptic connector according to claim 12 wherein said adapter housing includes an internal door disposed within said interior and movable between a door open position and a door closed position, in said door open position said fiber
20 coupling mechanism exposed through said adapter open end, in said door closed position said door covering said fiber coupling mechanism, said fiberoptic connector further comprising:

a cam surface carried on said connector housing and positioned to
urge said door from said door closed to said door open position as said connector
25 housing is inserted into said adapter housing to said fully inserted position.

17. A fiberoptic connector according to claim 12 wherein:
said connector housing includes a retaining clip carried thereon for
releasably connecting with said adapter housing;
30 said retaining clip including a movable end and a clip body having a fixed end secured to said connector housing, said clip body spaced from said connector housing to define a volume;

said retaining clip disposed for said movable end to be positioned
between said connector opening and said fixed end.

35

18. A fiberoptic connector according to claim 17 wherein said movable end is spaced from opposing surfaces of said connector housing by a distance less than a thickness of a fiberoptic cable secured to said connector housing.

19. A fiberoptic connector according to claim 12 wherein said connector housing contains a sealing ring disposed to seal against opposing surfaces of said fiber coupling mechanism when said connector is inserted into said adapter.
- 5 20. A fiberoptic connector according to claim 12 wherein a terminal end of said fiber is at a non-orthogonal angle with respect to a longitudinal axis of said fiber.
21. A fiberoptic connector according to claim 20 wherein said connector housing includes an internal cavity sized to accommodate flexing of said fiber.
- 10 22. A fiberoptic connector and adapter assembly comprising:
- a. a fiberoptic connector having:
1. an outer connector housing having a longitudinal connector axis;
2. an optical fiber disposed within said connector housing and having
15 a terminal end exposed through an opening in a leading end of said connector housing;
3. a cover carried on said connector housing and pivotally connected thereto to pivot between a cover open and a cover closed position, said cover in said cover closed position covering said opening,
20 said cover in said cover open position exposing said opening, said cover including a cam pin receiving slot;
4. a spring biasing said cover toward said cover closed position;
- b. an adapter having:
1. an adapter housing having a longitudinal adapter axis and having
25 walls defining an interior and an open end sized to receive said leading end with said longitudinal connector axis aligned with said longitudinal adapter axis;
2. a fiber coupling mechanism contained within said interior to couple with said optical fiber when said connector housing is inserted into said adapter housing to a fully inserted position;
- 30 3. a cam pin disposed within said interior to be received within said cam pin receiving slot and urge said cover from said cover closed position to said cover open position as said connector housing is inserted into said adapter housing to said fully inserted position.
- 35 23. A fiberoptic connector and adapter assembly according to claim 22 wherein said spring has an overcenter position, wherein said spring biases said cover toward said cover open position after said cover is rotated by said cam pin past said

overcenter position as said connector housing is inserted into said adapter housing toward said fully inserted position.

24. A fiberoptic connector and adapter assembly according to claim 22 wherein
5 said spring is pivotally mounted to said outer connector housing.

25. A fiberoptic connector and adapter assembly according to claim 24 wherein
said spring is a helical coil spring mounted under compression.

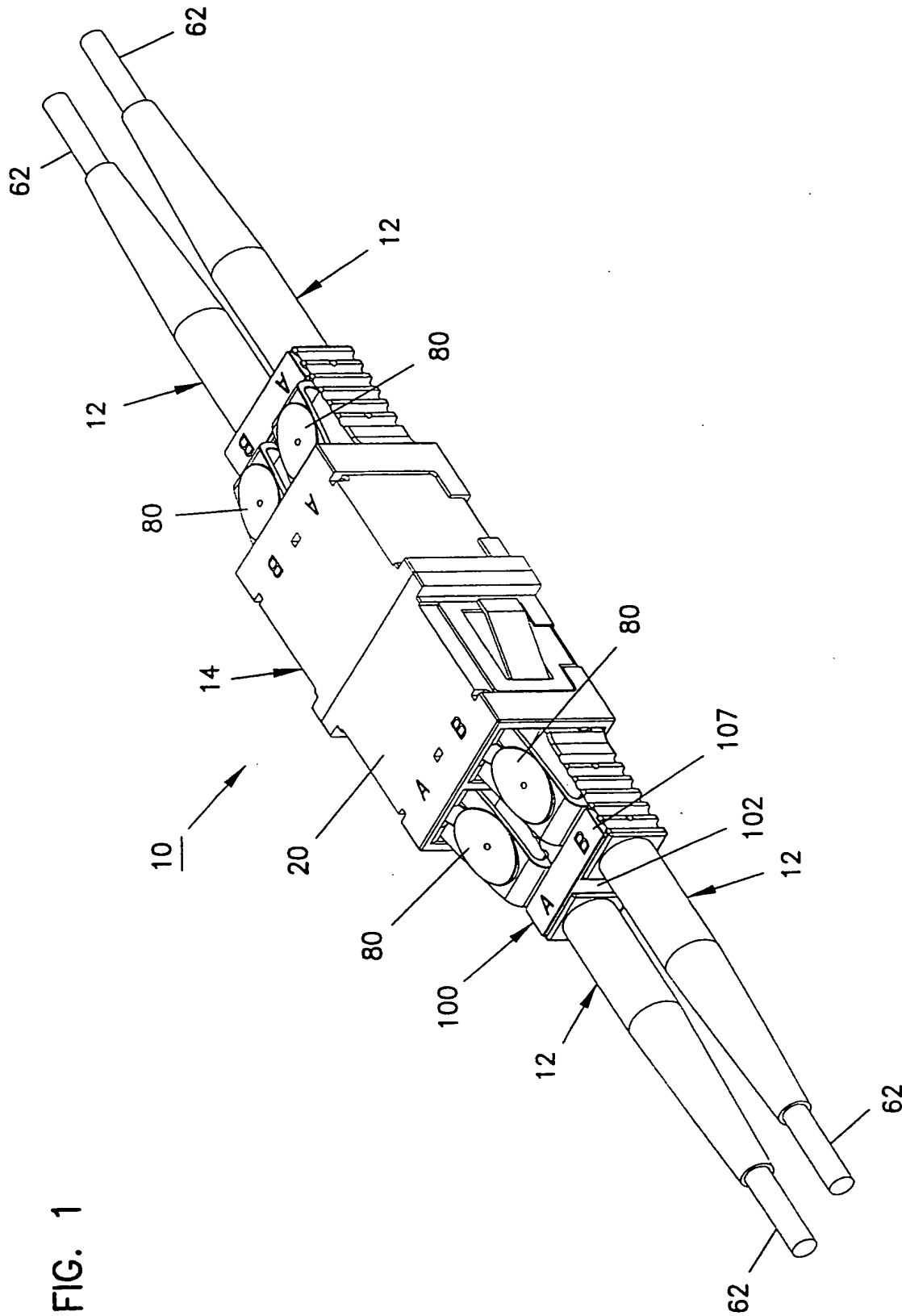
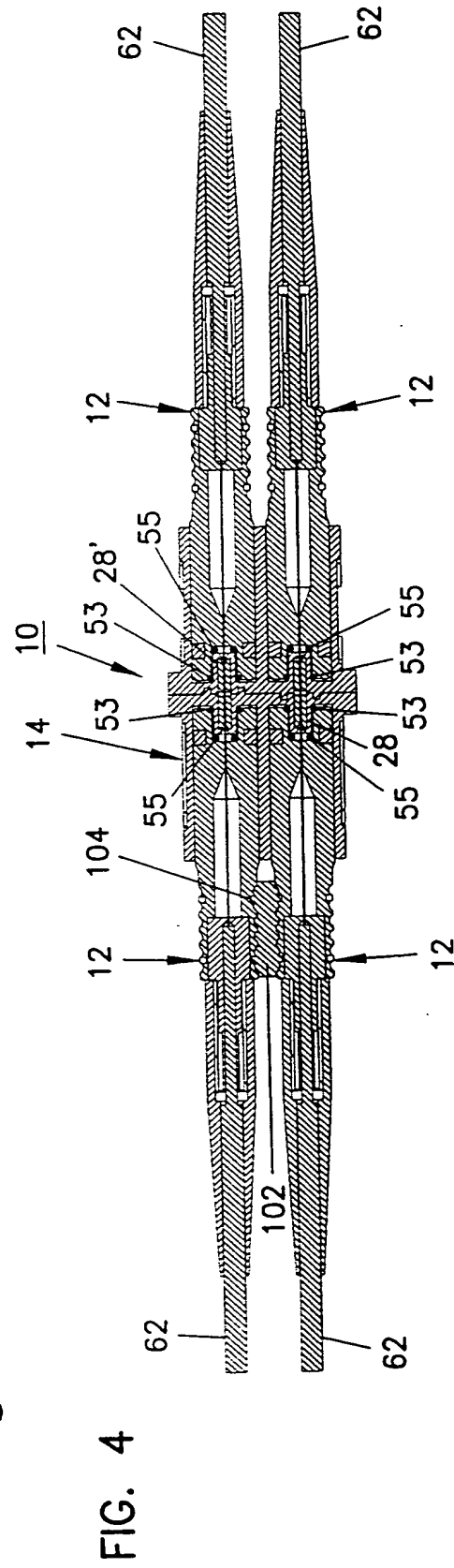
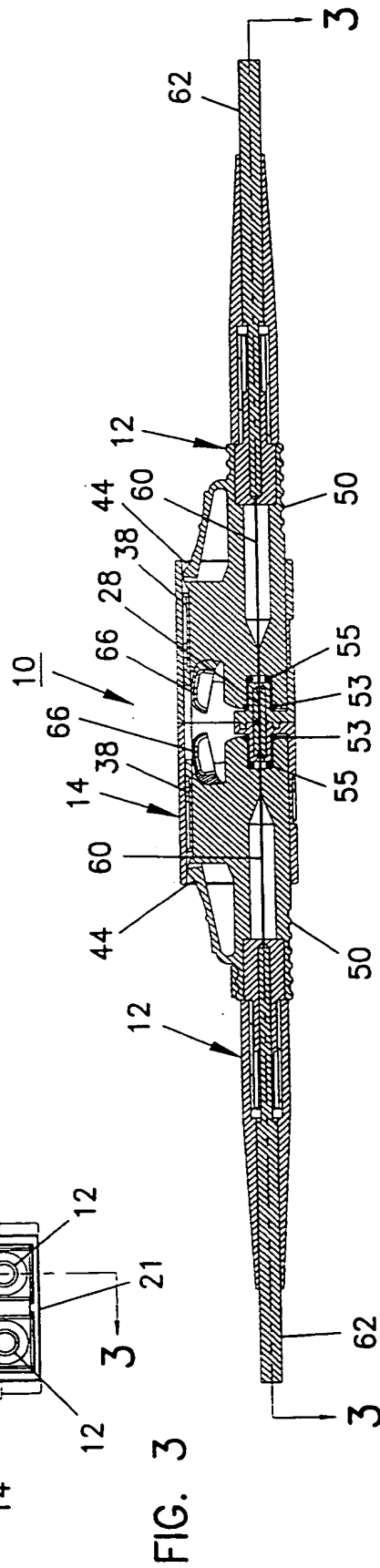
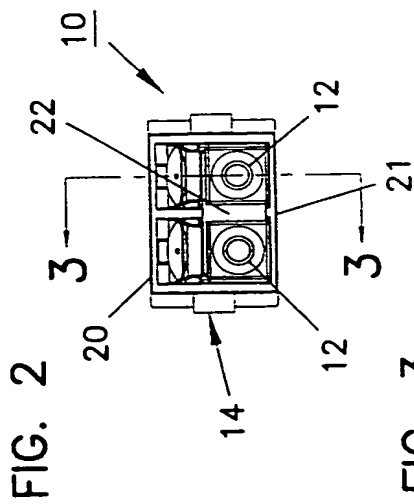


FIG. 1



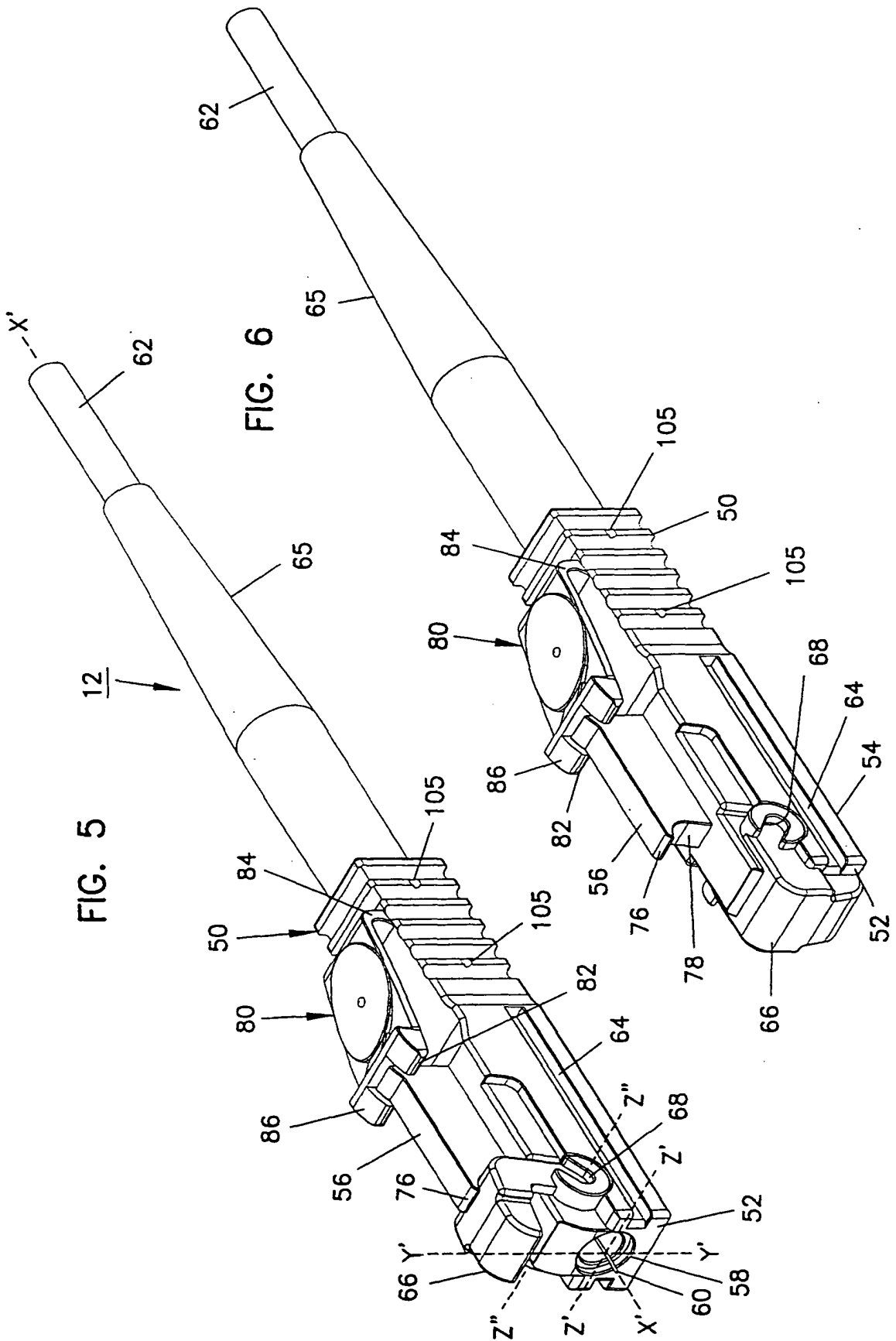
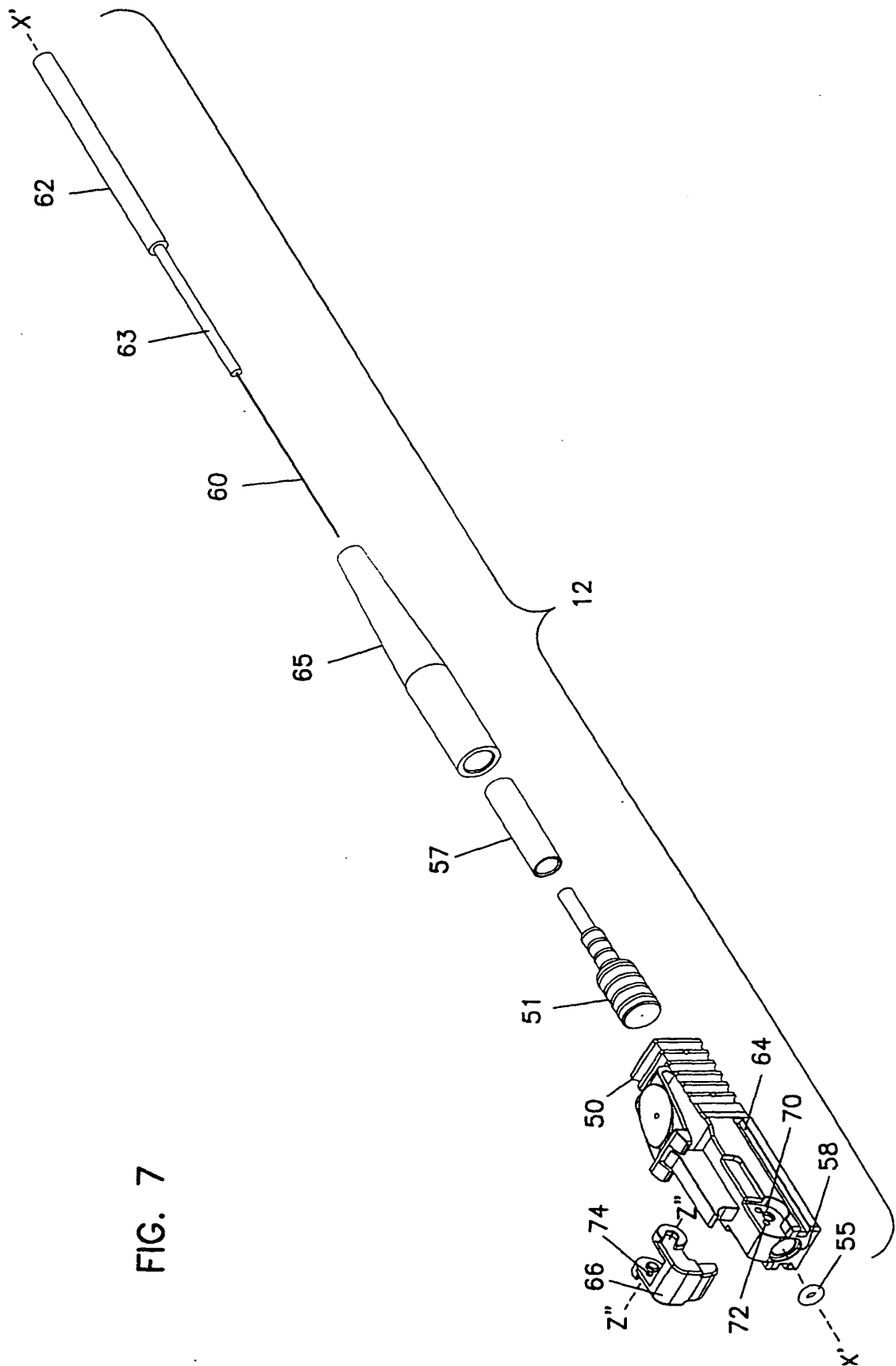


FIG. 7



SUBSTITUTE SHEET (RULE 26)

FIG. 8

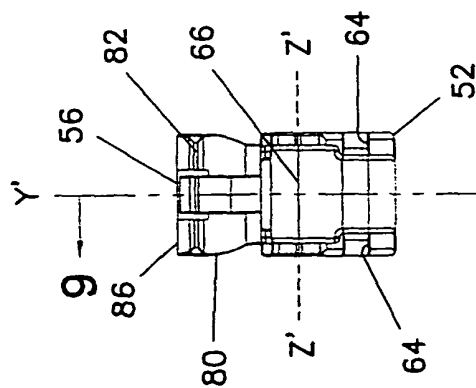
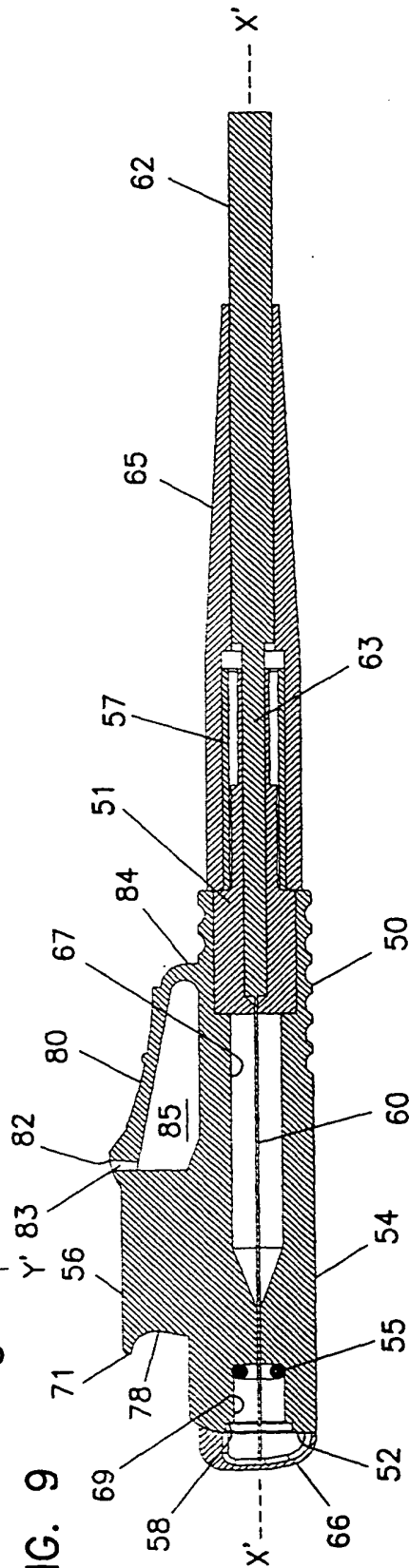


FIG. 9



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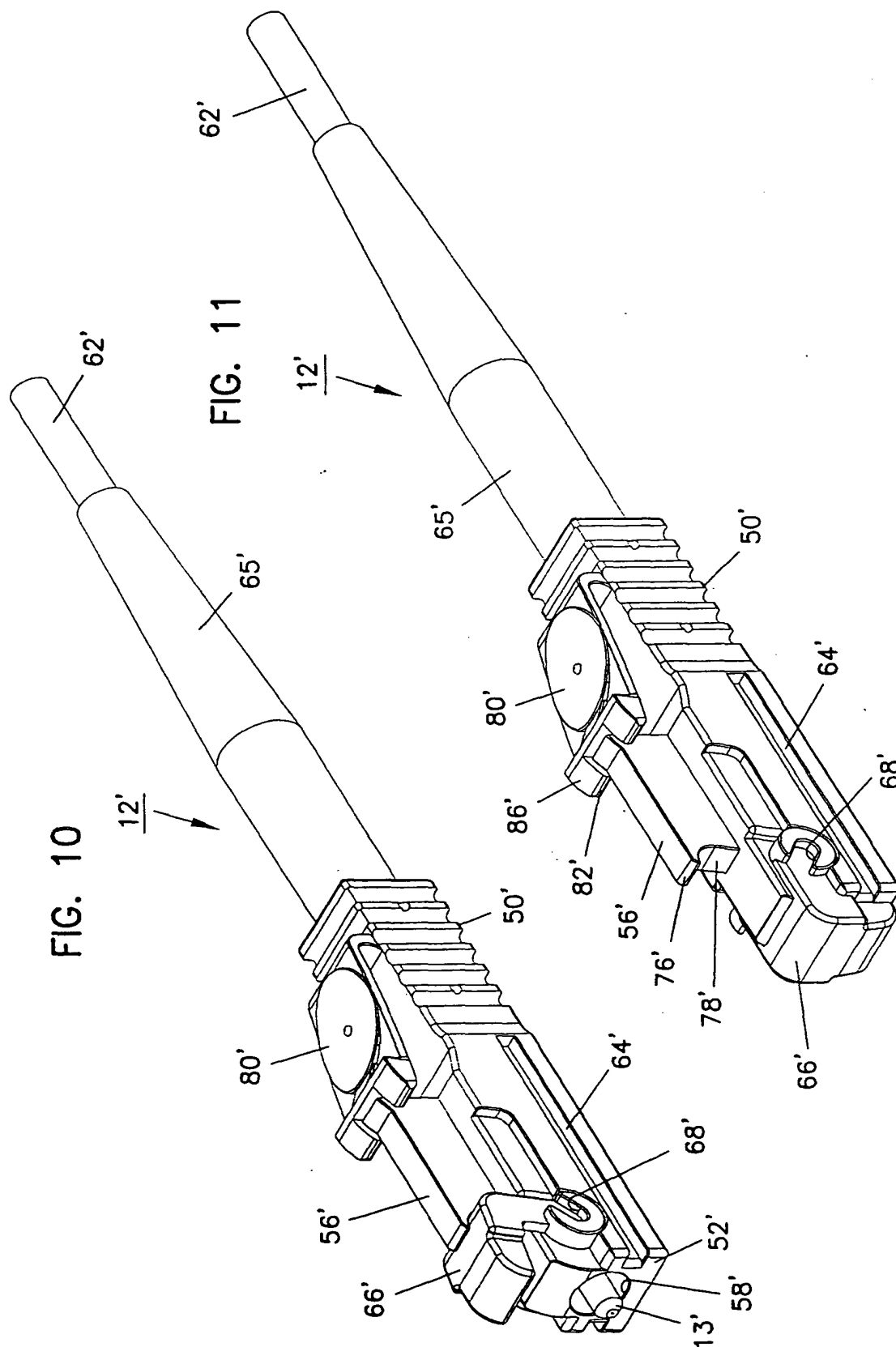


FIG. 12

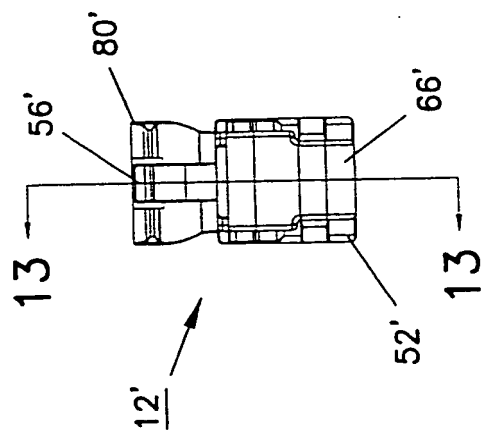
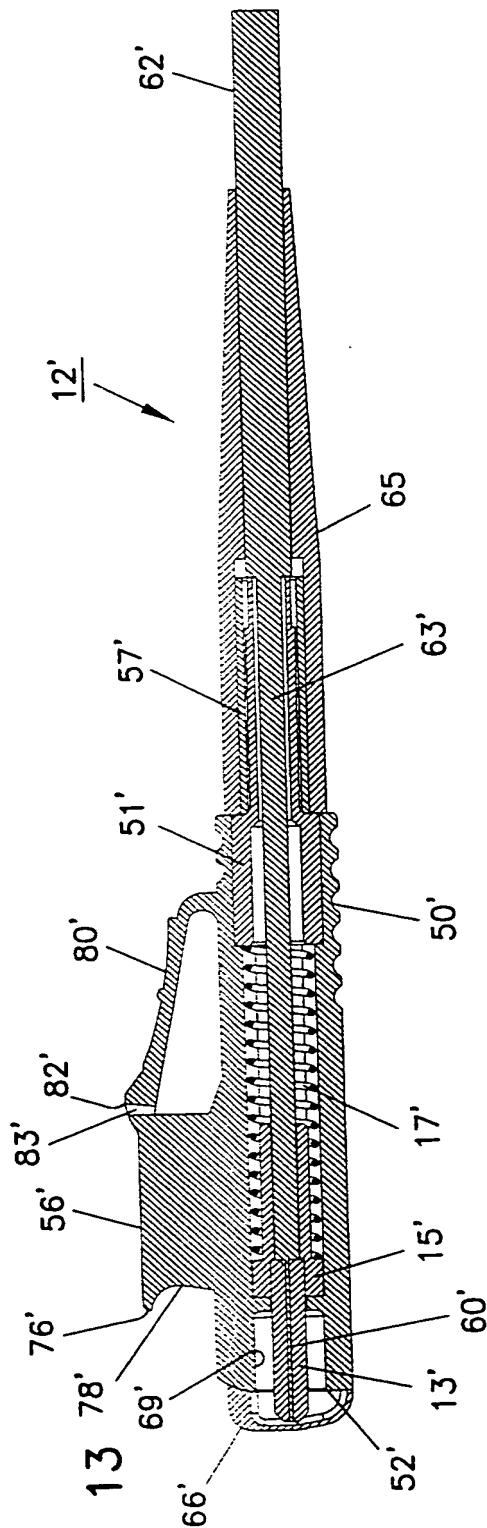


FIG. 13



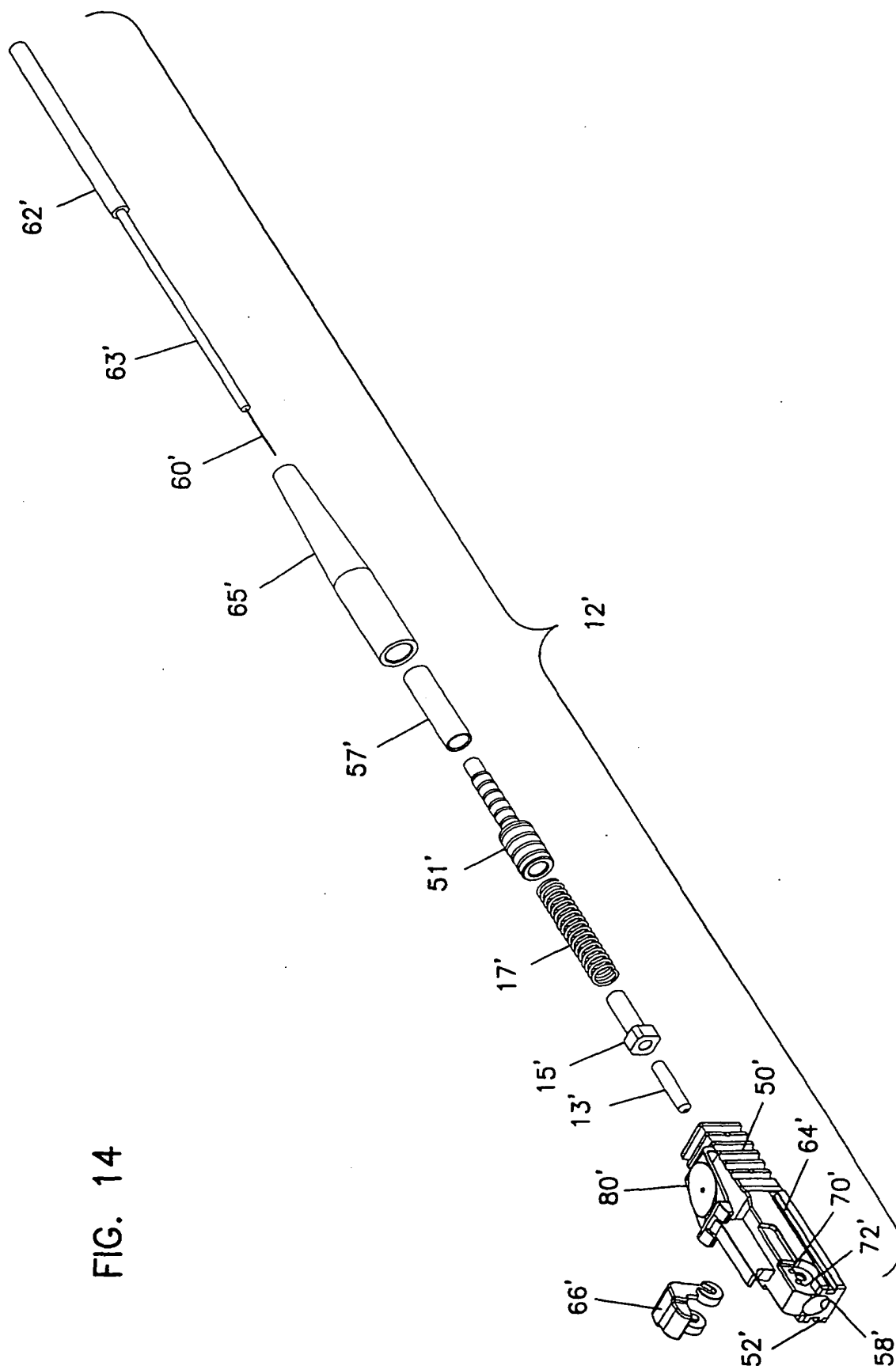


FIG. 14

FIG. 15

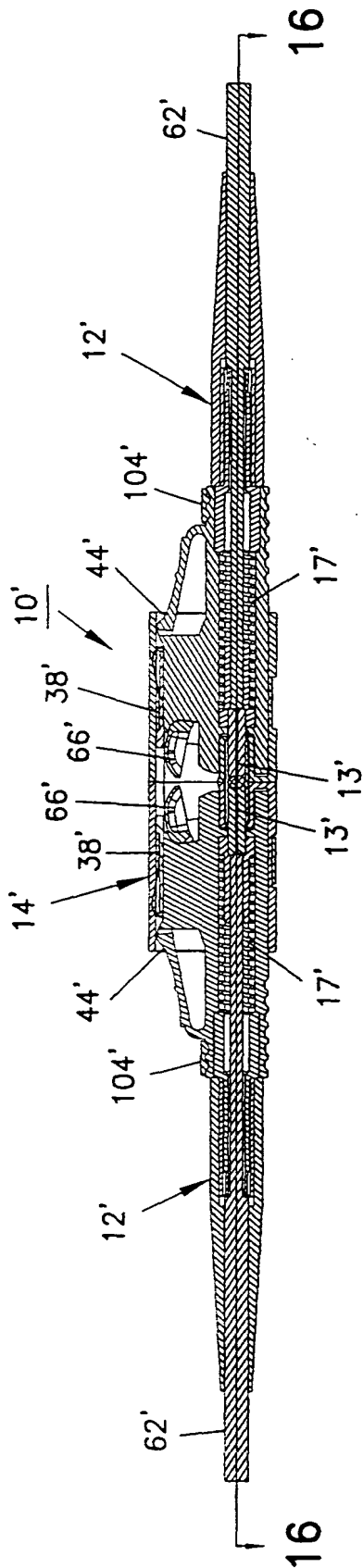
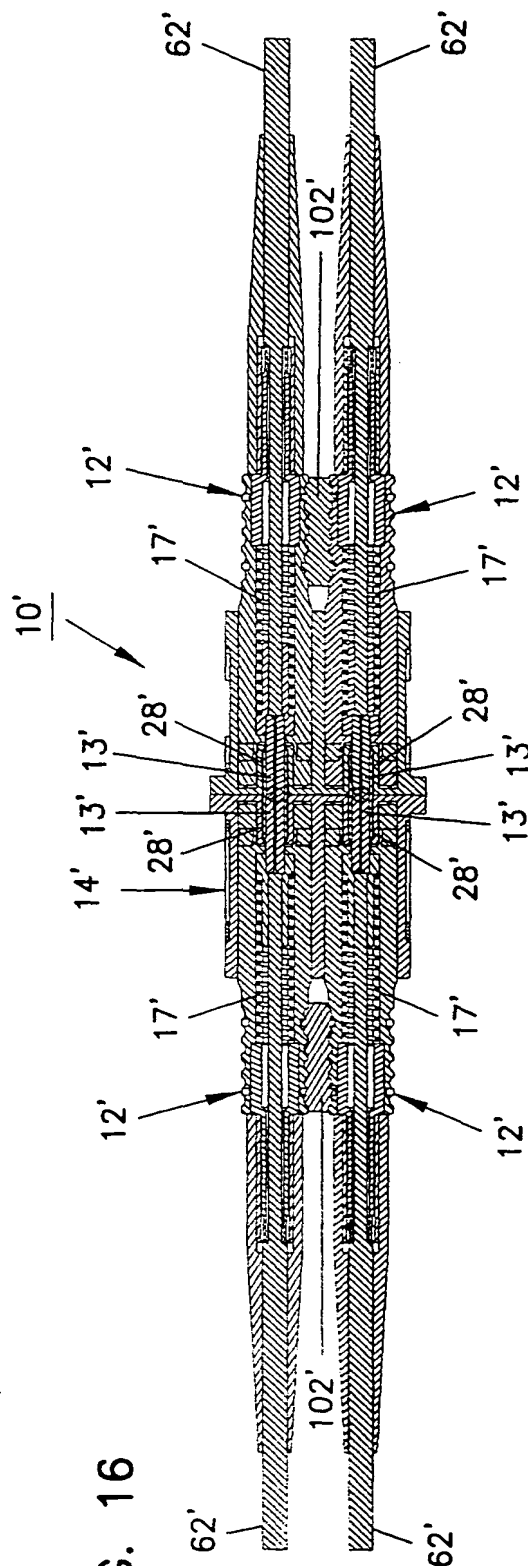
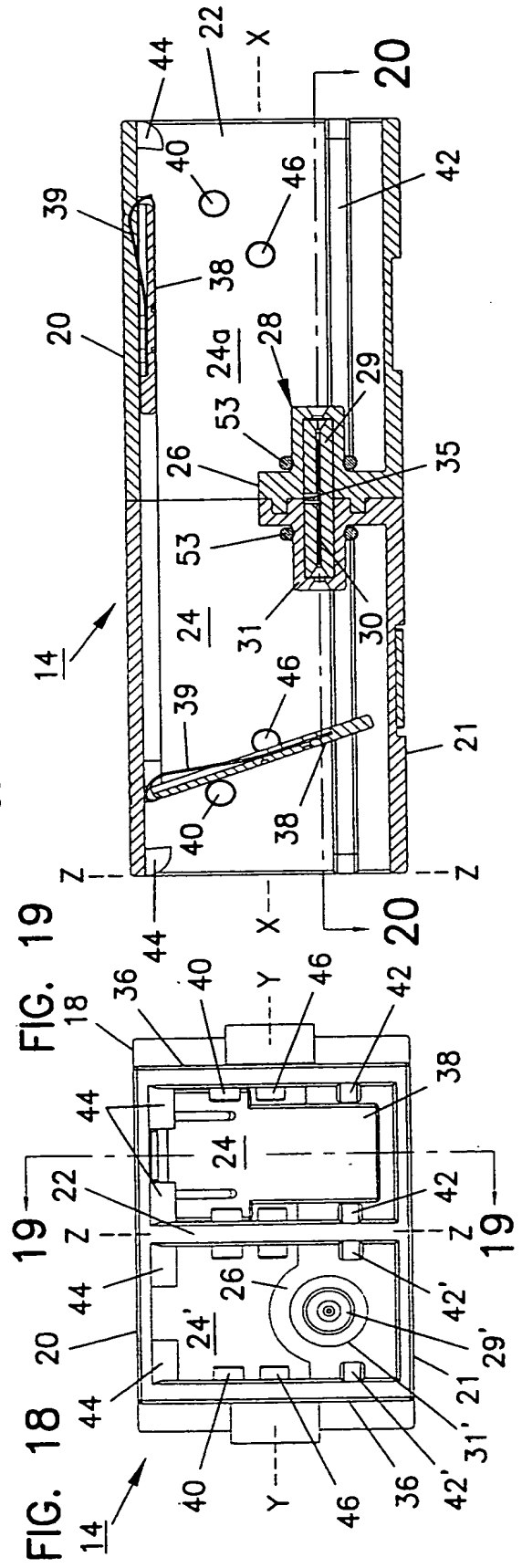
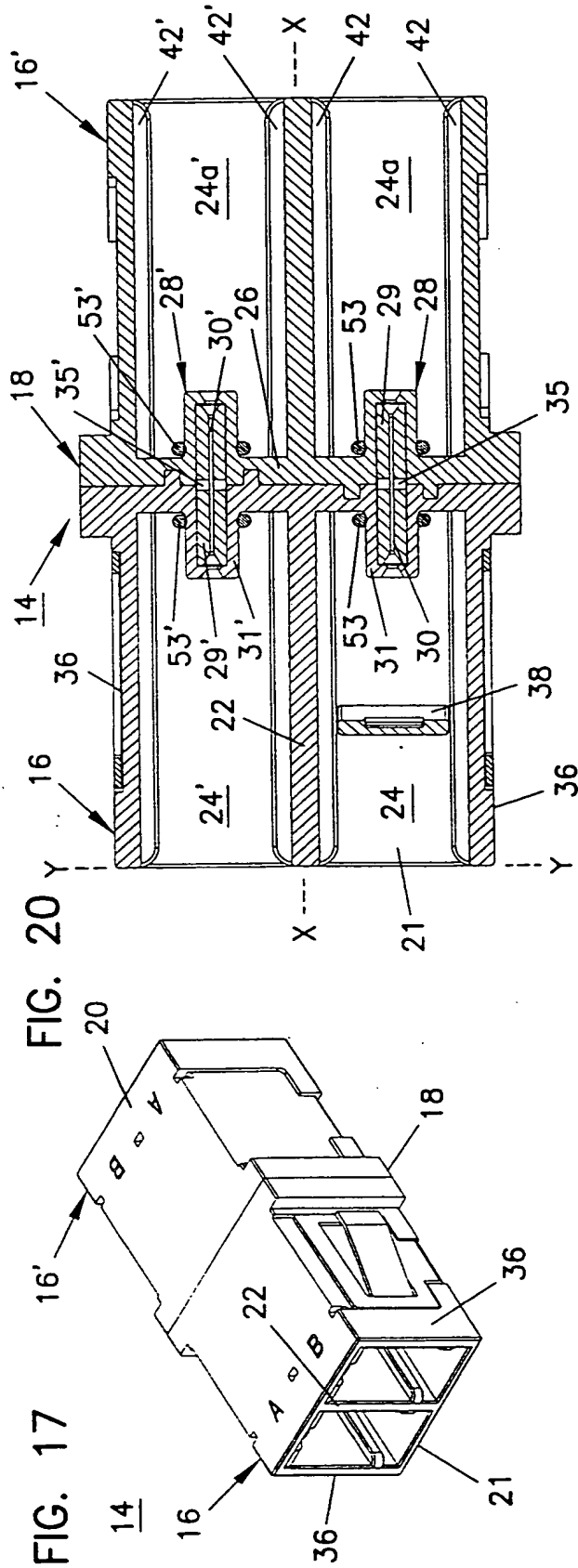


FIG. 16





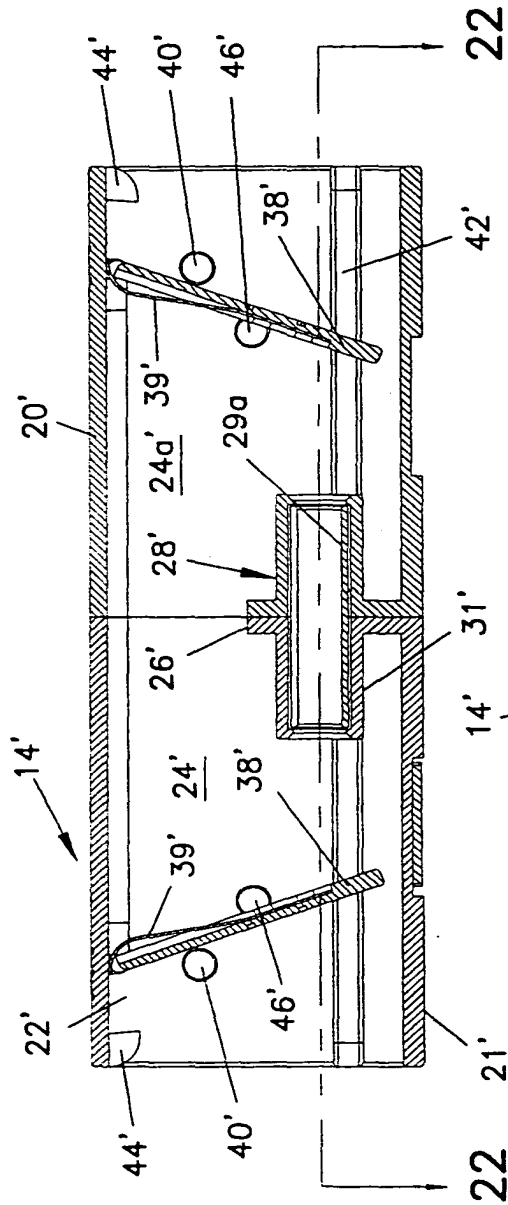


FIG. 21

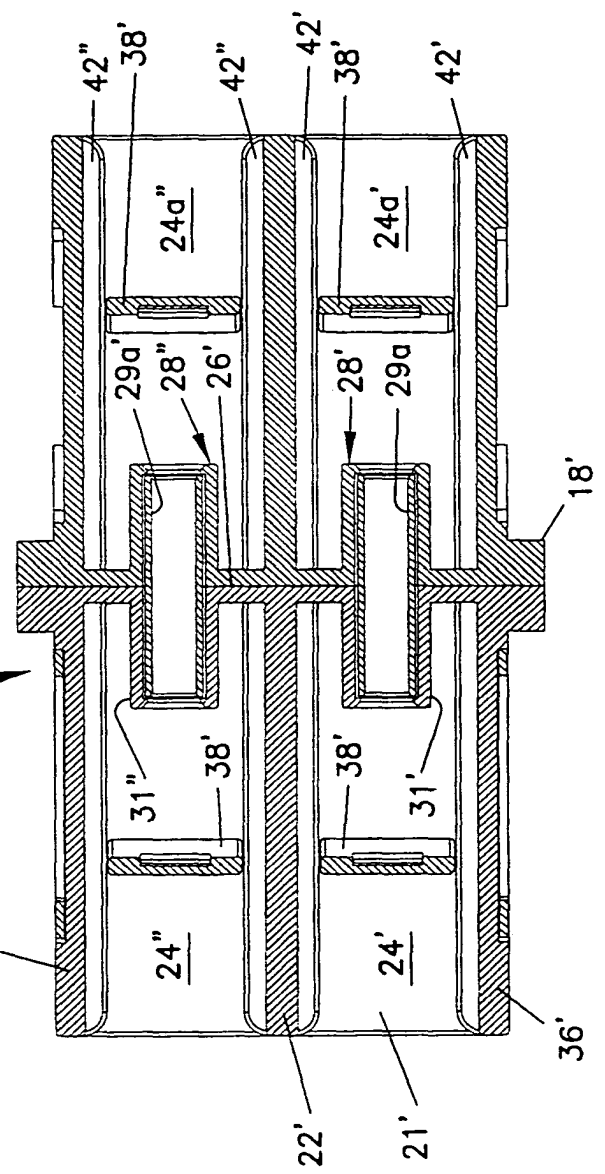


FIG. 22

FIG. 23

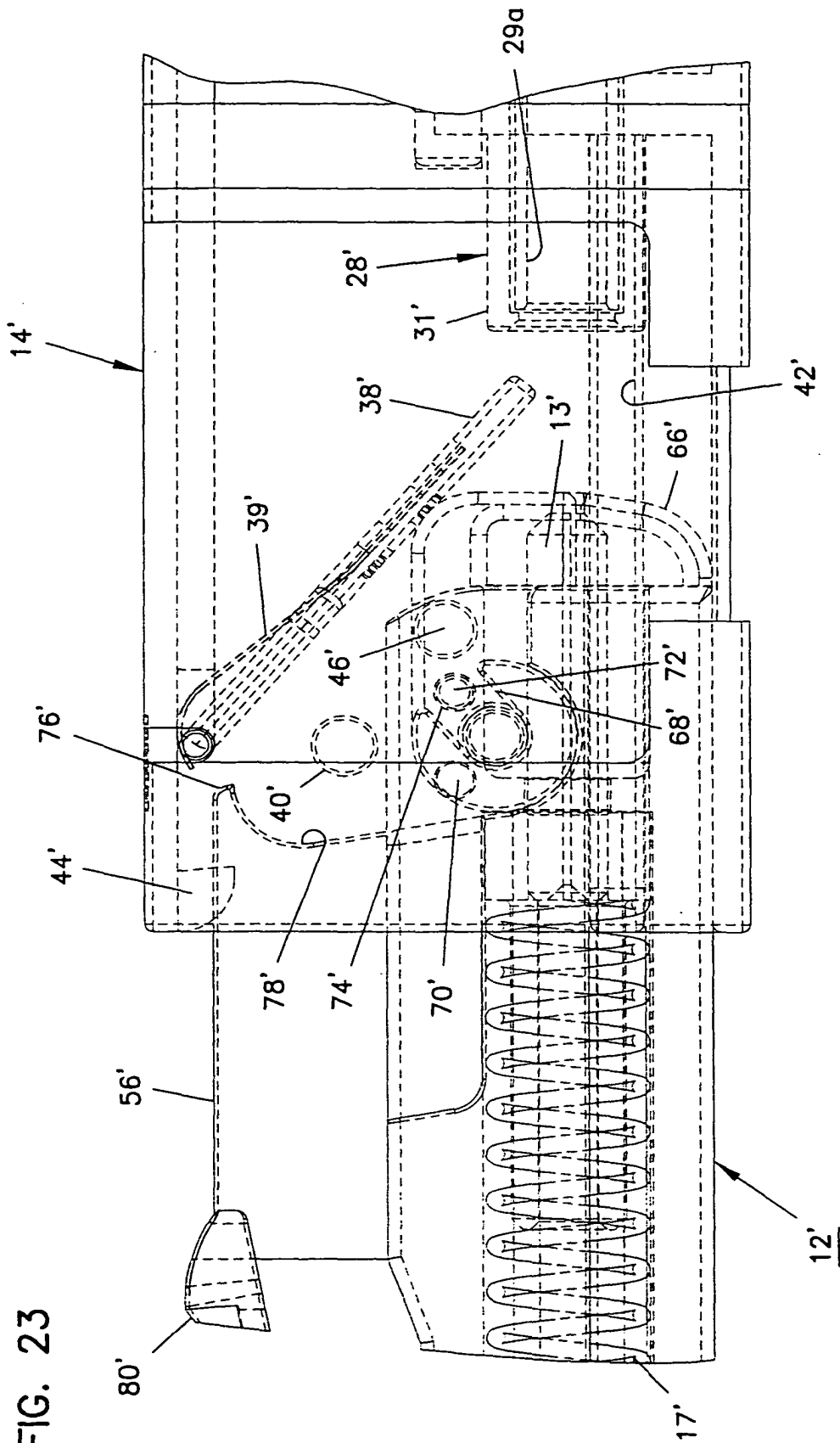


FIG. 24

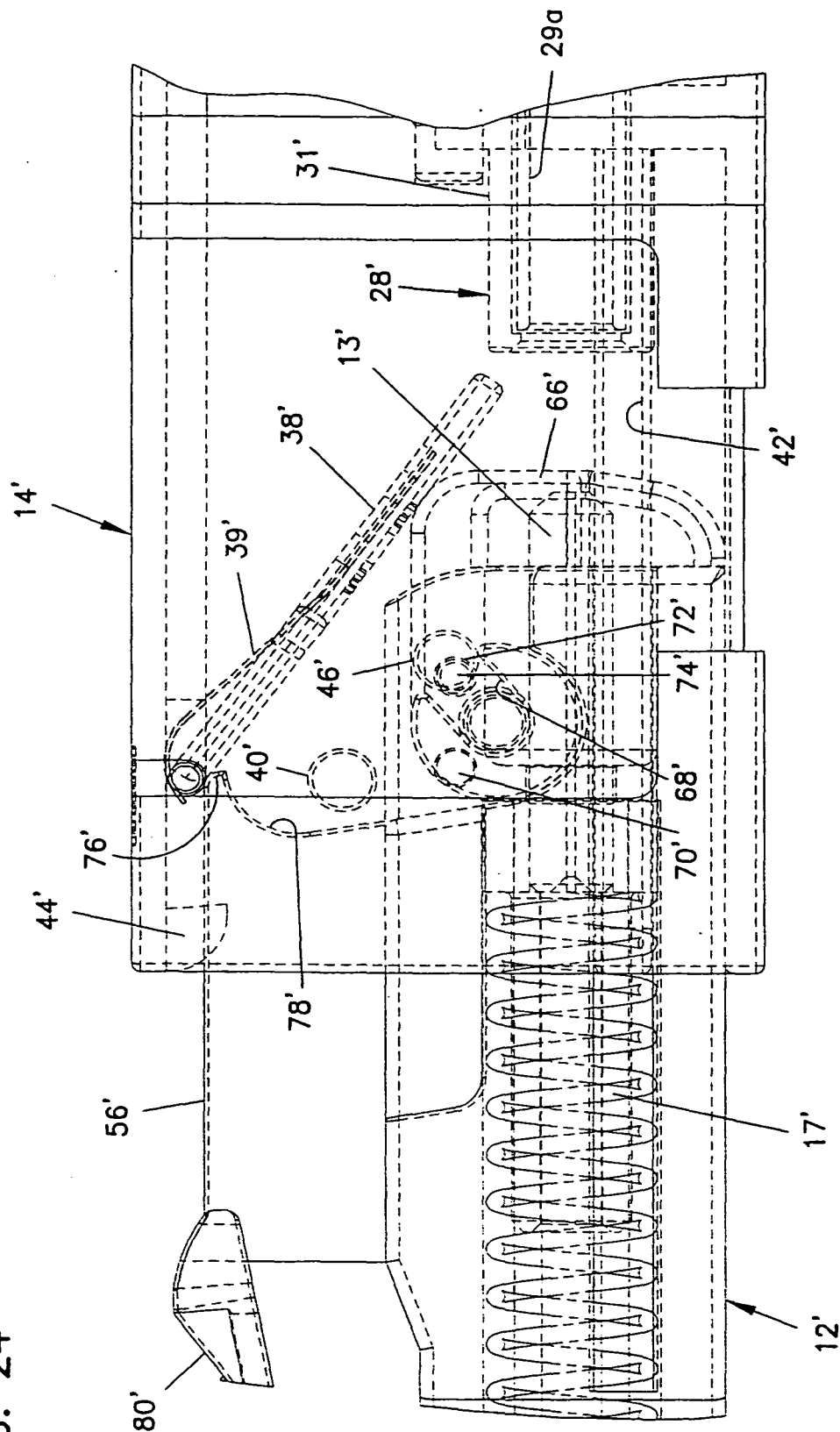
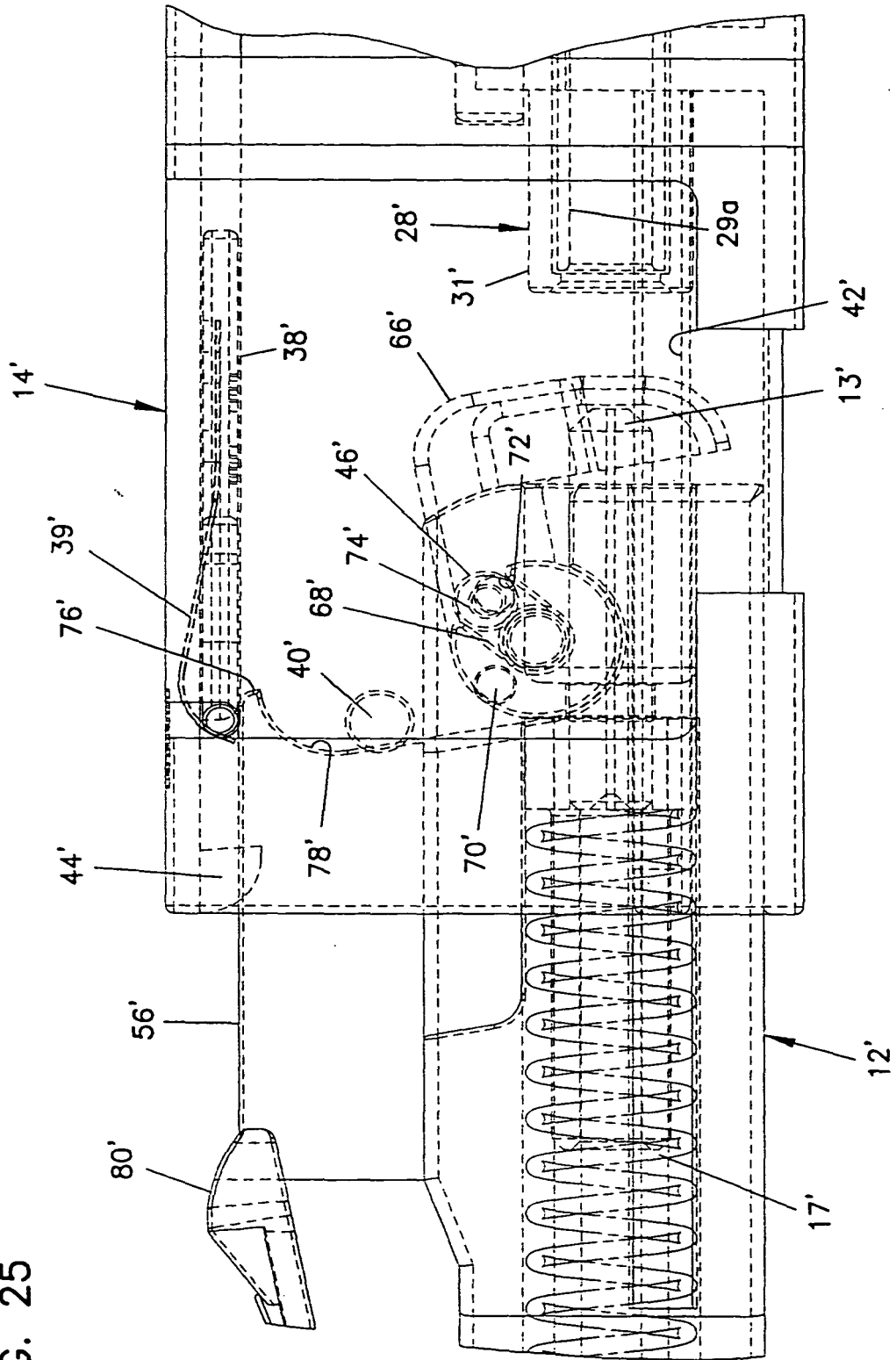


FIG. 25



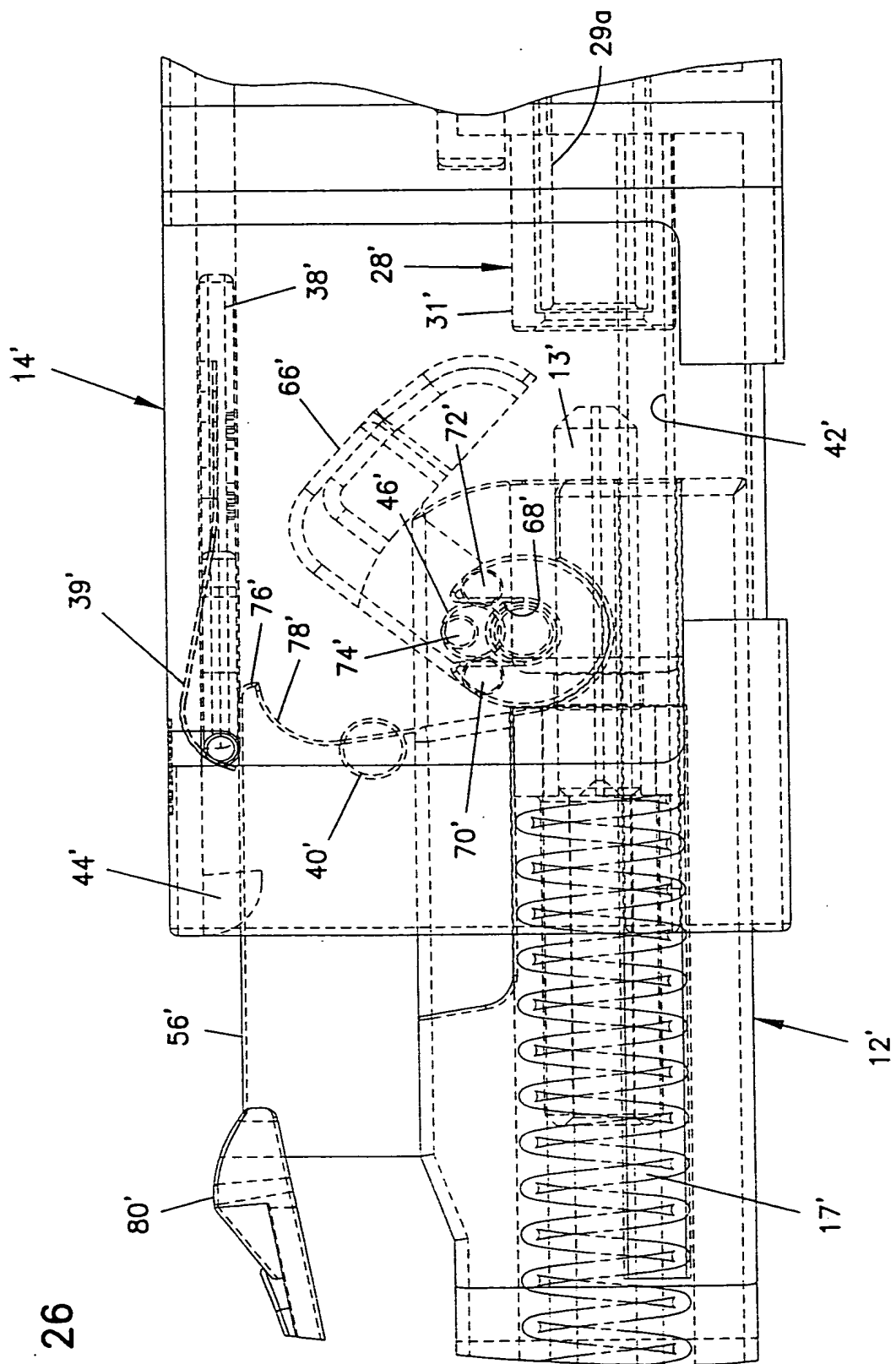


FIG. 26

FIG. 27

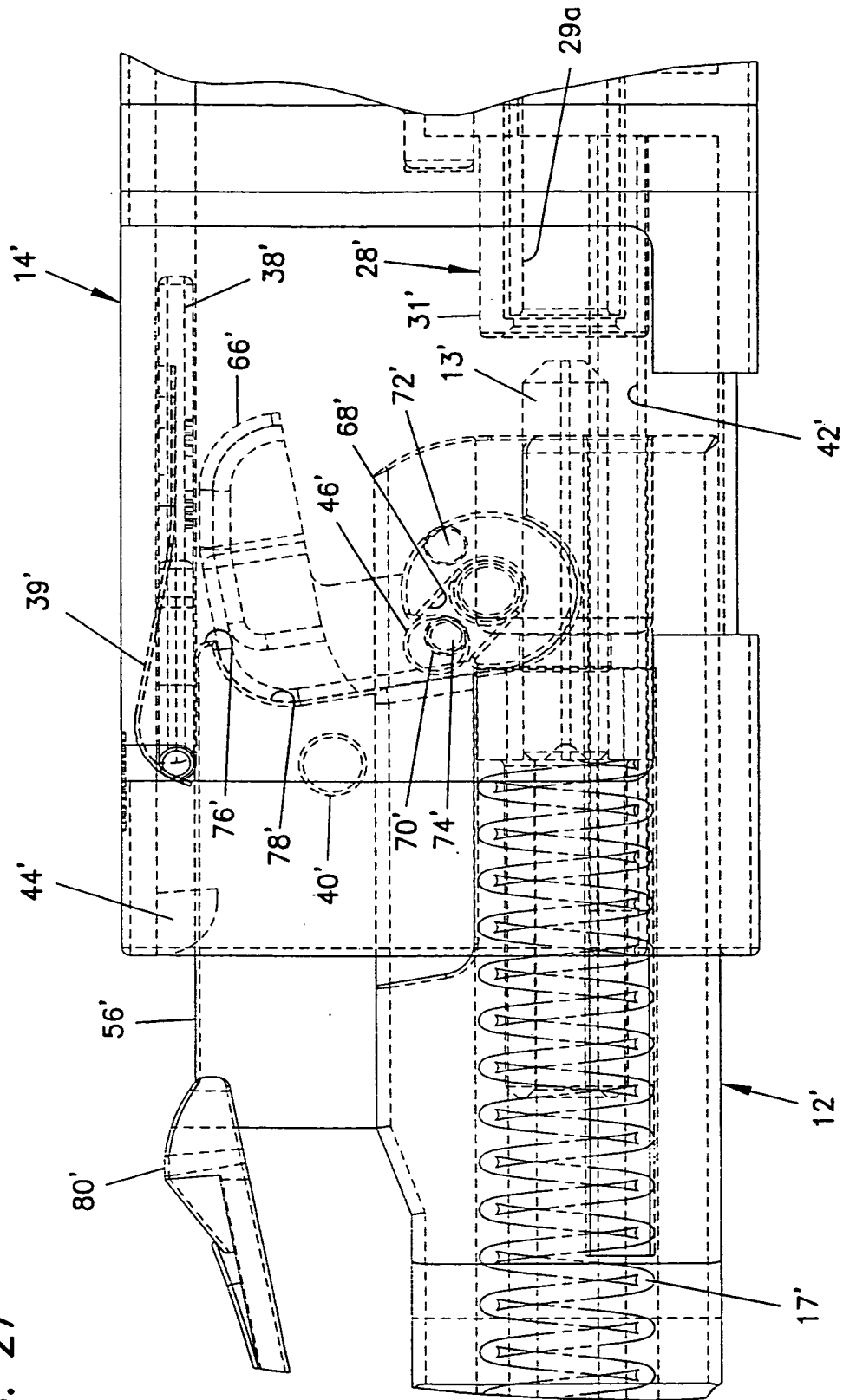


FIG. 28

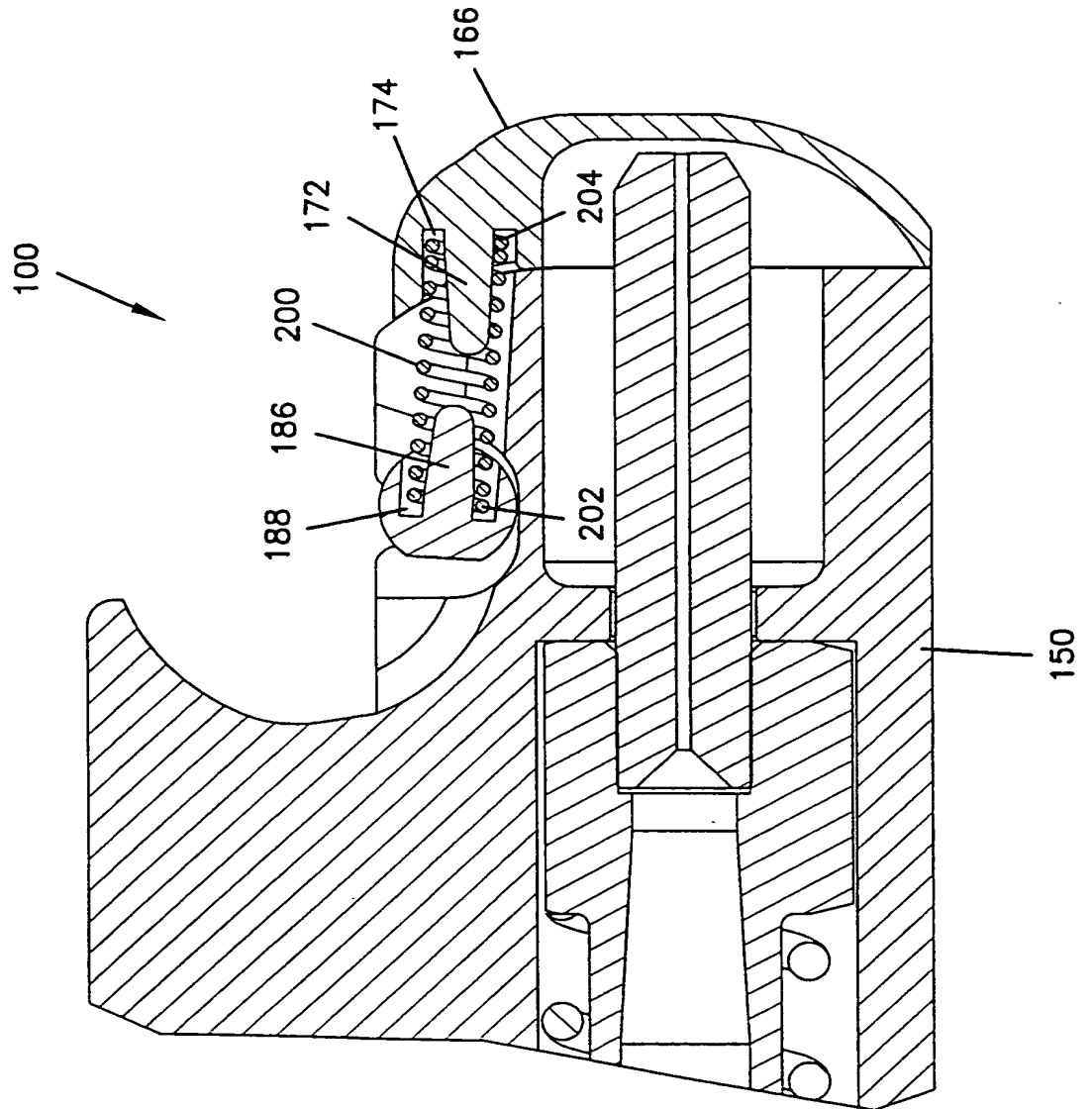


FIG. 29

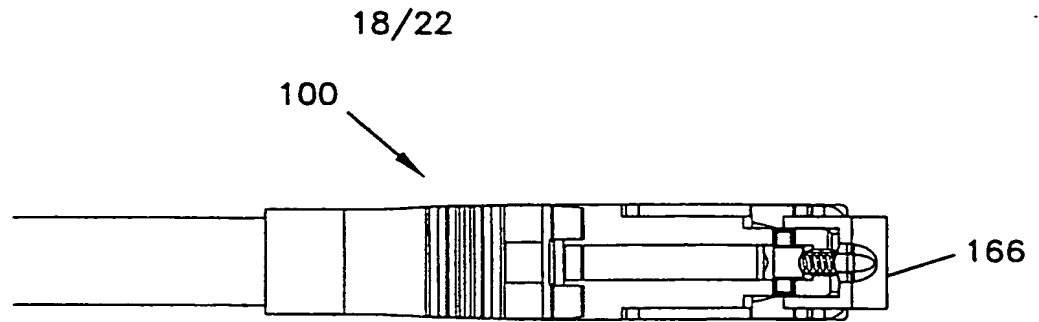


FIG. 30

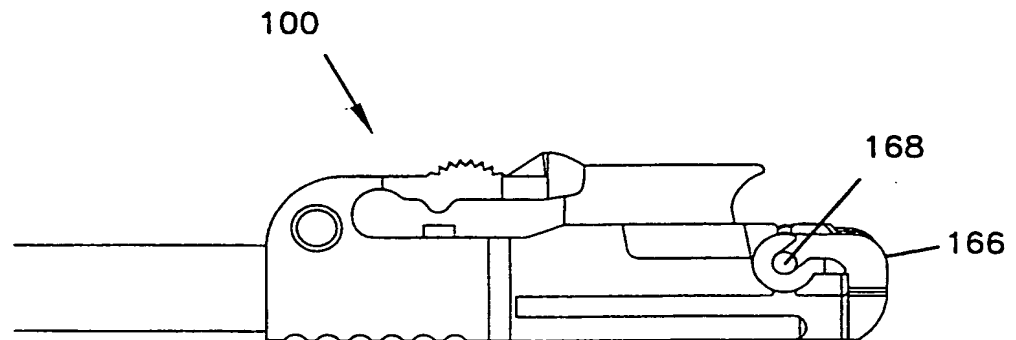


FIG. 31

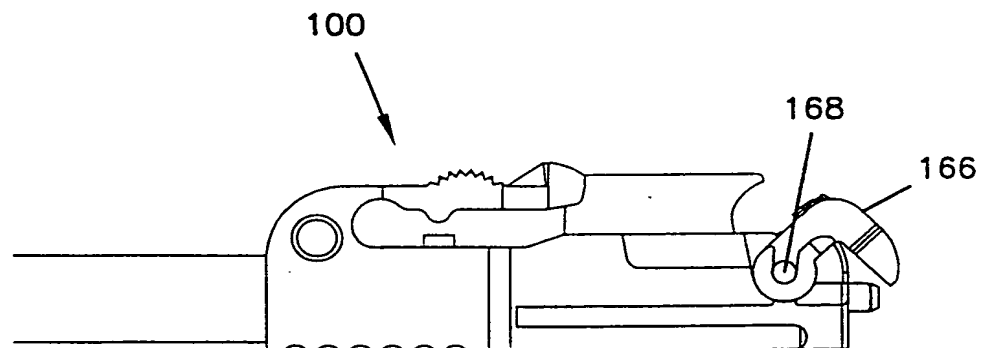
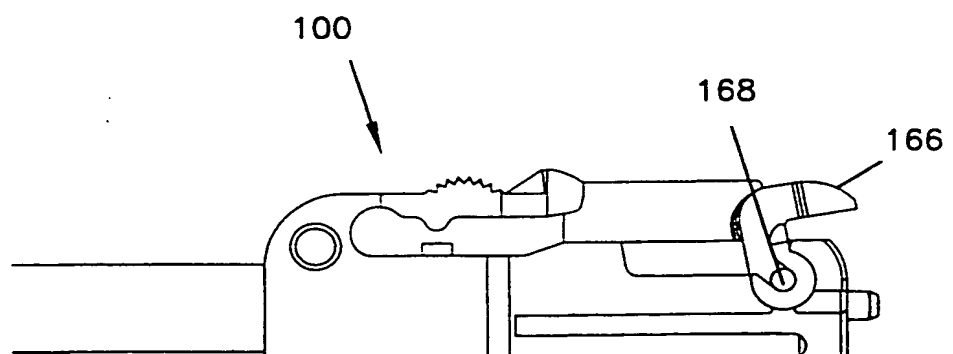


FIG. 32



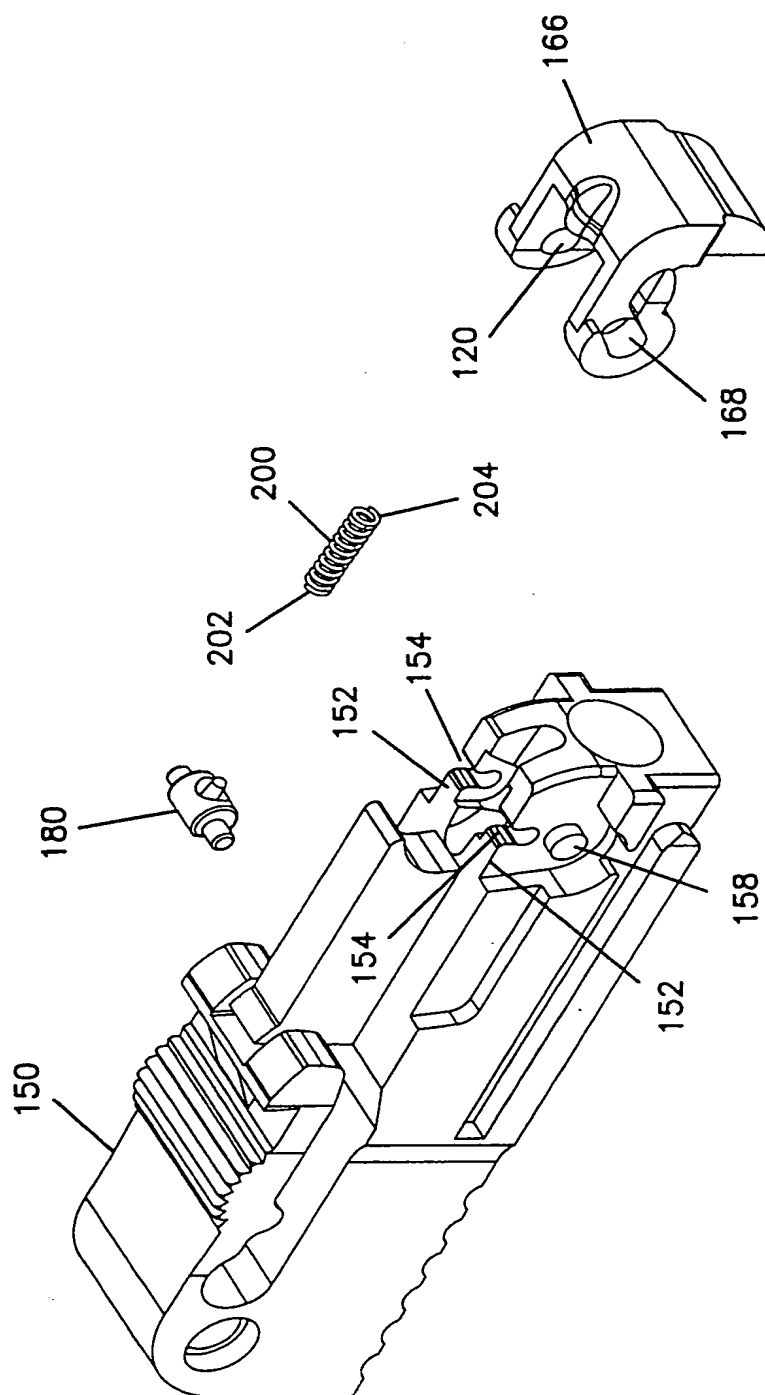


FIG. 33

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FIG. 35

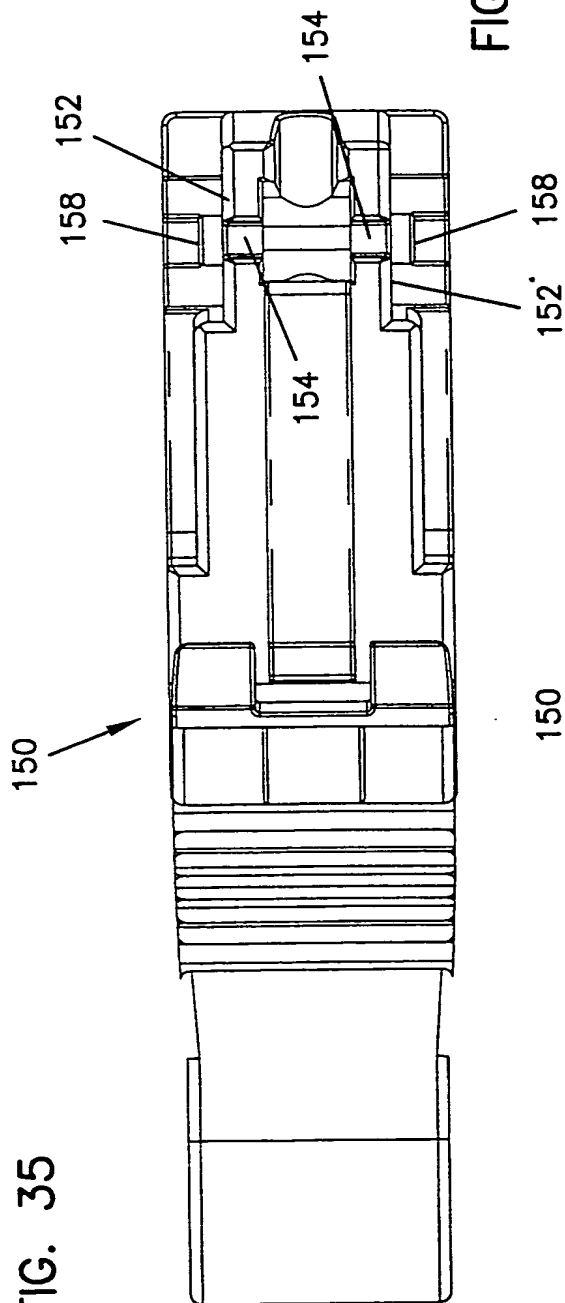


FIG. 36

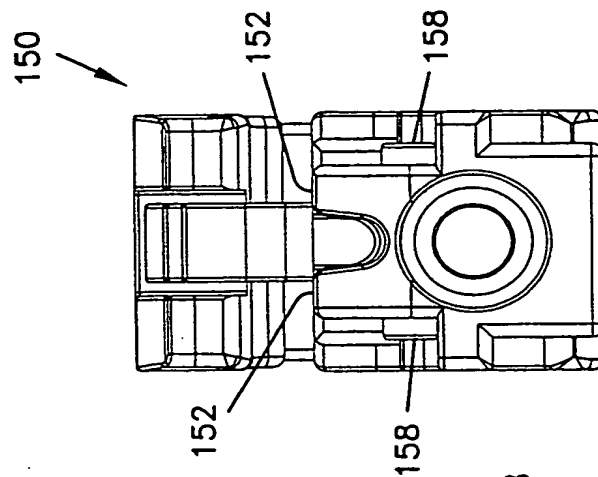


FIG. 34

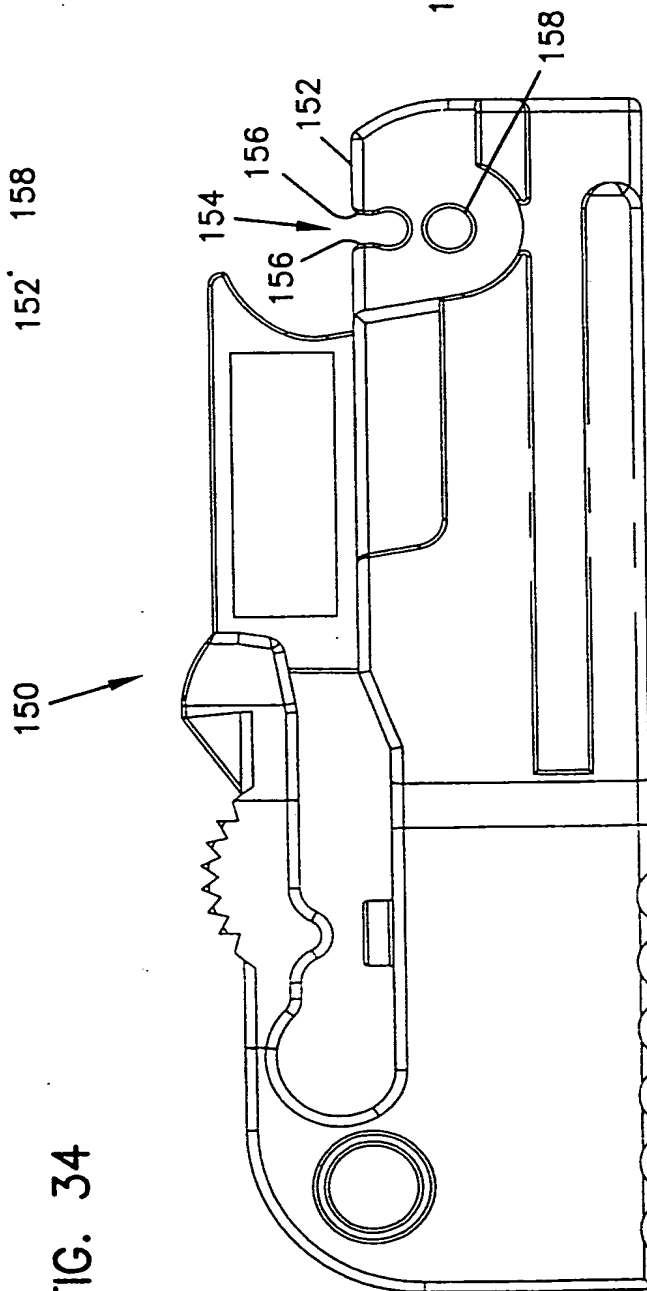


FIG. 37

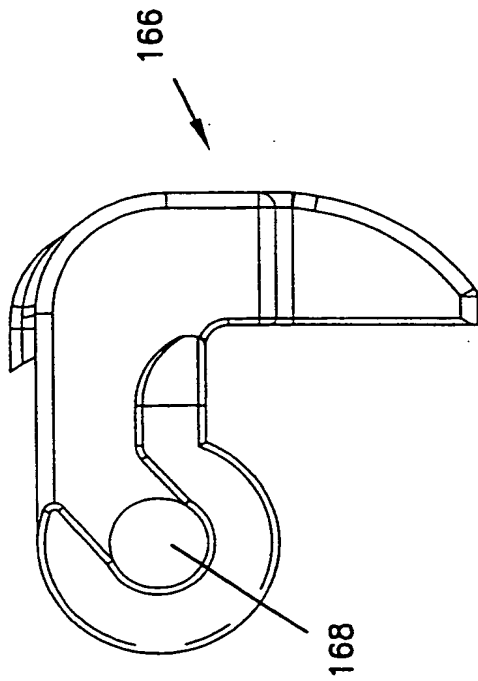


FIG. 38

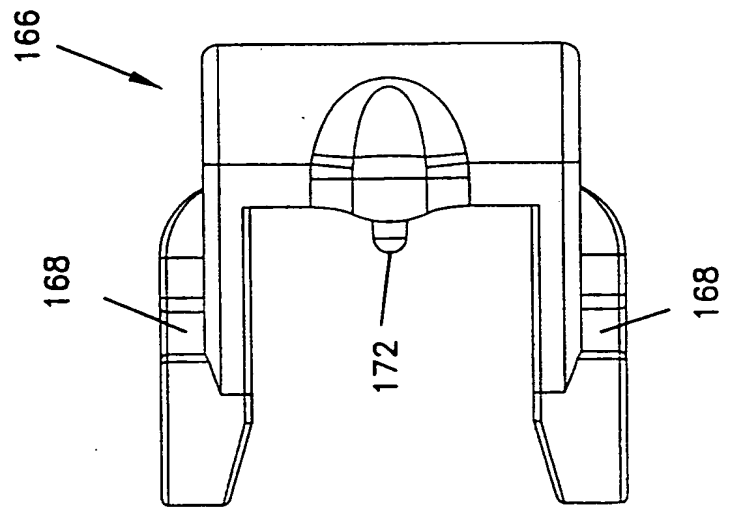


FIG. 39

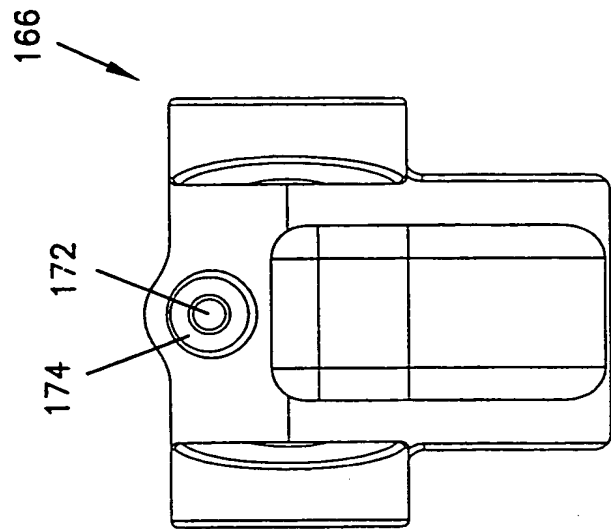


FIG. 40

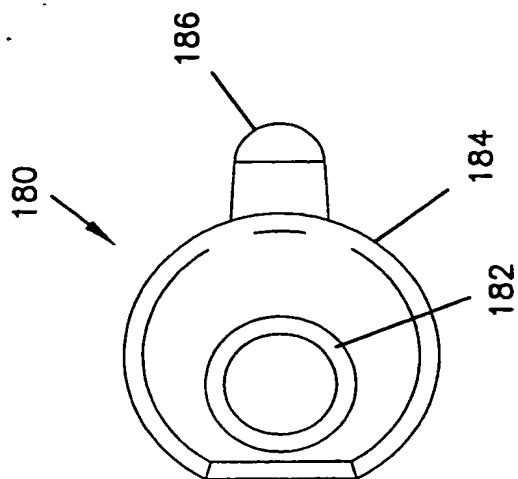


FIG. 41

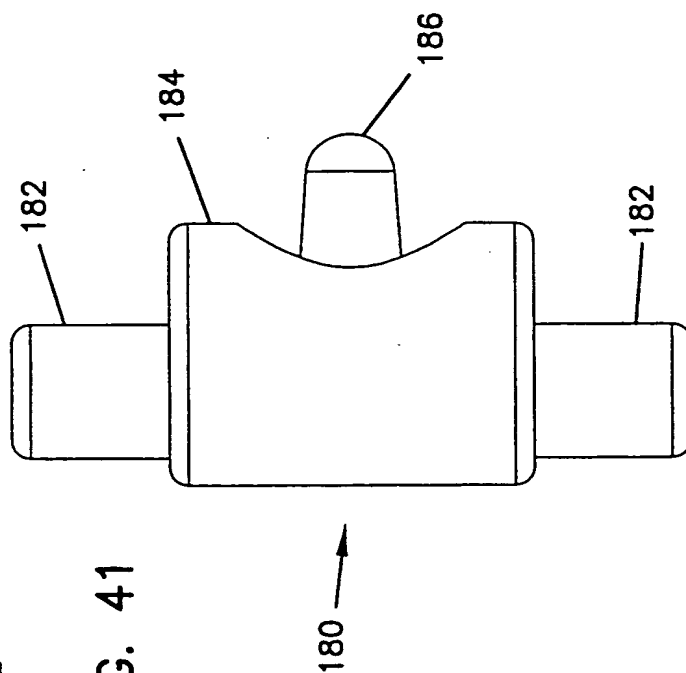
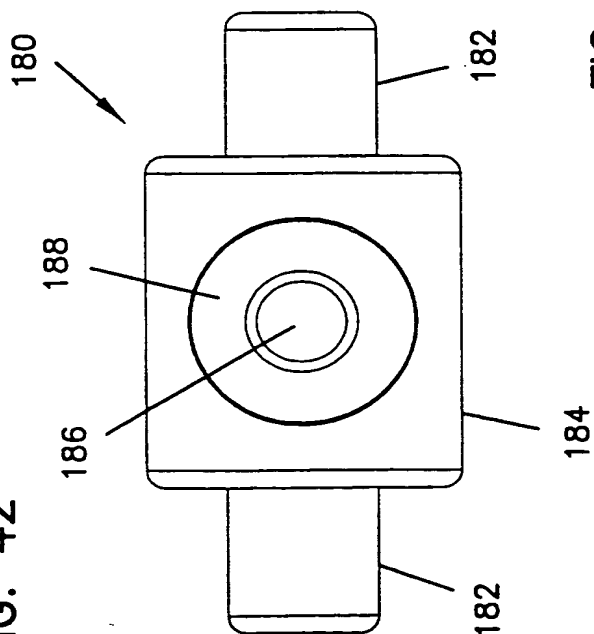


FIG. 42



INTERNATIONAL SEARCH REPORT

Intern. Application No.
PCT/US 99/20120

A. CLASSIFICATION OF SUBJECT MATTER G02B6/38 According to International Patent Classification (IPC) or to both national classification and IPC ⁷		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) G02B, H01R Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5348487 A (MARAZZI ET AL.) 20 September 1994, fig. 1-12 (cited in the application). --	1, 5- 12, 16, 17, 19, 22
A	US 5379362 A (KAWAMURA, S.) 03 January 1995, column 5, line 14 - column 9, line 5. --	1, 5, 7- 9, 13, 17, 22
A	GB 2112173 A (THOMAS AND BETTS CORP.) 13 July 1983, fig. 1, 2. --	1, 3, 4, 12, 13, 14, 15, 22-25
A	US 4913514 A (THEN, J.L.) 03 April 1990, --	1, 12, 22
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 11 November 1999		Date of mailing of the international search report 11 01 2000
Name and mailing address of the ISA -- European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016		Authorized officer GRONAU e.h.

ANHANG

zum internationalen Recherchen-
bericht über die internationale
Patentanmeldung Nr.

In diesem Anhang sind die Mitglieder
der Patentfamilien der in obenge-
nannten internationalen Recherchenbericht
angeführten Patentedokumente angegeben.
Diese Angaben dienen nur zur Unter-
richtung und erfolgen ohne Gewähr.

ANNEX

to the International Search
Report to the International Patent
Application No.

PCT/US 99/20120 SAE 247891

This Annex lists the patent family
members relating to the patent documents
cited in the above-mentioned inter-
national search report. The Office is
in no way liable for these particulars
which are given merely for the purpose
of information.

ANNEXE

au rapport de recherche inter-
national relatif à la demande de brevet
international n°

La présente annexe indique les
membres de la famille de brevets
relatifs aux documents de brevets cités
dans le rapport de recherche inter-
national visée ci-dessus. Les renseigne-
ments fournis sont donnés à titre indica-
tif et n'engagent pas la responsabilité
de l'Office.

In Recherchenbericht angeführtes Patentedokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
US A 5348487	20-09-1994	EP A2 570652 EP A3 570652 EP B1 570652 AU A1 38490/93 AU B2 658999 JP A2 7281055 DE C0 59205913	24-11-1993 01-12-1993 03-04-1994 25-11-1993 04-05-1994 27-10-1994 09-05-1996
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EP A1 733922	25-09-1996	AU A1 48153/96 CA A4 2171494 JP A2 8362275 NO A0 961107 NO A 961107	03-10-1996 23-09-1996 11-10-1996 19-03-1996 23-09-1996